Utilization of Semantic Annotations in Interactive User Interfaces for Large Documents

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Abstract: With new techniques, such as Microformats or RDFa, for integrating semantics into existing web formats, we expect a strong increase of semantically annotated documents in the web. This paper describes a new approach for utilizing semantic annotations to improve the user interface for large text documents by guiding the user's attention to semantically annotated text sections using interactive focus+context techniques. We describe an implementation of the concepts in a patent information system.

1 Introduction

Semantic technologies based on the Resource Description Framework (RDF) allow users to describe Web contents and resources in a structured way, so that applications can access the information without the need for complex pre-processing. Within the PATExpert project[1] semantic technologies are used to encode concepts and metadata contained in patents to make them accessible to new applications. A technical problem so far has been the seamless integration of semantic annotations into web formats in general and into patent document formats in particular.

There are various ways to associate semantic annotations with the contents of web documents, for example by linking to external RDF data. Microformats on the other hand offer a simpler approach by defining metadata directly within HTML using existing HTML attributes. Hovever there are limitations in favor of simple usage that concern the extensibility, ambiguity and the non standard conformance.

The GRDDL (Gleaning Resource Descriptions from Dialects of Languages) [GRD07] standard gives another solution to the problem of how to extract RDF from various formats. It delegates the extraction logic to transformation scripts, which 'know' about the specific encoding of semantic annotations and can transform inline annotations into RDF. Currently there are two generic approaches for embedding RDF in XHTML. One is RDFa [Adi07] the other is eRDF (Embeddable RDF) [Tal06]. Both can be used in combination with GRDDL (but restricted to XML).

With these upcoming techniques we expect a strong increase of semantically annotated

[1]Project homepage: `http://www.patexpert.org`

documents on the one hand and also their usage within semantic search engines. The direct annotation of contents in particular adds a new feature: a one-to-one connection of (invisible) metadata descriptions with visible content elements. It therefore becomes possible to apply the document layout also for the presentation of metadata. Instead of using graph-based layout algorithms for RDF data, we can now simply overlay the text structure with associated metadata.

The overall goal addressed in this paper is to improve the readability of documents by new semantic annotation driven interaction and visualization techniques that firstly, draw the user's attention to annotated elements by using interactive focus+context techniques, secondly display the associated metadata structure in order to connect similar concepts in the text, and thirdly integrate semantic search and highlighting capabilities.

2 Related Work

There have been various approaches for visualizing semantic structures. In general, we can distinguish between macro-level and micro-level visualization approaches. Macro-level visualizations are applied to large triple sets and aim at getting deeper insights about patterns in their structure. The typical presentation is by using graphs. Examples for macro-level visualizations can be found in [ABM04, Spo07]. Micro-level visualization approaches on the other hand focus on the presentation of smaller triple sets and individual triples. Well known examples are Welkin [MC] and IsaViz [Pie02]. Beside graph-based approaches, special vocabularies, such as the Fresnel RDF Display Vocabulary [PBKL06], can be used to define the presentation of RDF.

However, existing micro-level visualization approaches for the semantic web do not directly combine the presentation of text with the presentation of metadata. In contrast, our approach uses the text structure and aditionally adds metadata aspects on top of the text. The focus is on improving the presentation of large texts, e.g. patents, by using interactive techniques to draw the user's attention to text segments with associated metadata. Other sections can be put in the background using a fish-eye distortion technique [Fur86, Bed00].

With context sensitive presentation of structures derived from semantic annotations, the navigation between multiple documents that share the same concepts or properties can also be improved. This aspect has also been addressed in semantic wikis [VKV$^+$06, RK06], where semantic annotations are used for navigation and filtering. In contrast to the existing semantic wiki approaches, we interactively overlay the text with annotations and thus allow a more direct navigation.

3 Semantic Annotation Driven Focus+Context Techniques

The hypothesis of our approach is that text fragments which are semantically annotated are of special interest. As a consequence, the attention of the user should be drawn to these fragments. In order to reduce the on-screen distance between two key terms and at the same time keep some of their original context visible and readable, we reduce the vertical size of the text section between the two terms and apply a distortion function to its content. This distortion function will cause text lines in the middle of the section, which presumably contain few contextual information for either key term, to be compressed more than those at the beginning or end of the section, in the proximity of one of the key terms. The top part of figure 1 shows a partly collapsed and the botton part a fully collapsed section.

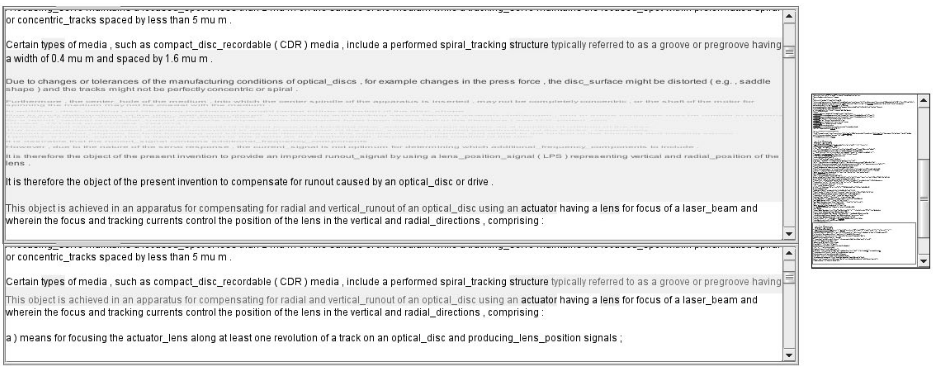

Figure 1: Semantic Annotation Driven Text Distorsion

The distortion function f will take two parameters, x and a, where x is the relative vertical position of a line of text in the text section ($x = 0$ for the first line, x close to 1 for the last), and a is the ratio of the current vertical size of the section and its original, uncompressed size. $f(x, a)$ then denotes the relative vertical position of the distorted line of text. For uncompressed sections ($a = 1$), we require the distortion function to cause no distortion at all, so that $f(x, 1) = x$. For highly compressed sections (a close to 0), the distortion function must retain $f(0, a) = 0$ and $f(1, a) = 1$, but have similar values for x around 0.5, to place middle lines very close together, which in turn allows keeping above average line heights for lines at the beginning and end of the section.

We define our example distortion function by linearly interpolating the identity function $f_1(x) = x$ for $a = 1$ and a fifth degree parabola centered in the domain [0,1] and normalized to the codomain [0,1] for $a = 0$: $f_2(x) = 16(x - \frac{1}{2})^5 + \frac{1}{2}$. This results in our distortion function $f(x, a) = a\ f_1(x) + (1 - a)\ f_2(x)$. In order to scale the height of the individual lines in accordance with the overall distortion, we render them at $f'(x, a)$ times their compressed but undistorted height.

There are various ways the user can interact with the view. The basic interactions are expanding and collapsing all or selected sections, which can either be selected manually or can be filtered via search, as described in the next section. User interaction triggers an animated transition. The distortion level is stageless and can be controlled by the user, either with the mouse wheel or by the duration the mouse key is pressed. Also an overview is given in a separate window that allows for quick navigation (right part of figure 1).

4 Highlighting of Semantic Search Results and Metadata Structure

The expected increase in semantically annotated documents makes semantic based searching more feasible. In contrast to traditional textual searching, the explanation of a search hit may be more difficult in semantic searching. Due to the possibility to find synonyms and hyponyms, the actual search string may not be found in the document itself. Also the subject and object of a relation may be in a remote location to the verb. Today's search engines already offer the possibility to highlight regions of text to explain the relevance of a search hit. But with complex search queries containing many terms the text may get cluttered with highlighted text and the user's attention is lost. Therefore we see a necessity for interactive highlighting and explanation.

This requires essentially three things. First, a representation of the search query, which may be either textual or graphical. Figure 2 shows a graphical representation that allows selecting parts of a query to be highlighted in the text. Second, the extracted RDF model of the annotated document in which the initial search already took place. This structure is now used to rerun the selected part of the query to identify the instances that are responsible for counting this document as a hit. And third, the essential part, a linkage between the RDF model and the annotated document. The linkage, i.e. the subject and object position in the text, can be stored either as URI attachments or by using RDF reification. In the PatViz framework we store the linkage information as URI attachments. URIs are composed as follows: <namespace><patent-number><section><start-pos><end-pos>, where start and end-pos are the token positions in the patent text.

Figure 2 shows the result of a highlight interaction. The user clicked on the left part of the PatViz Query Visualization representing a semantic search query. This query comprises a subject, a relation and an object. The detail view below shows the full text of a result document and highlights all semantic annotations which relate to the selected query part. The highlighting is realized by showing additional semantic information near its textual representation. This information can now be used to navigate further in the document, e.g. by showing other occurrences of annotations of the same type. Highlighting also takes place in the overview of the whole document.

The highlighted parts are derived from RDF statements attached to the patent document. The following triples (namespaces are ommitted) have been extracted by an automated process. Instances refer to specific text tokens. The position in the text has been stored as simple pairs of sentence and token numbers. Instances are related to others and are connected to ontology concepts. The underlying semantic formalism has been described in more detail in [GKK$^+$07, GBS$^+$06]. The triples show two instances, one of type `auto:actuator` and one of type `ordo:lens`, connected by a relation `sumo:hasPart`. The triples are visualized in the first sentence of figure 2 as linked text nodes with additional type information.

```
pat:EP0805439_A1#claims_1_13-1_13 rdf:type     auto:actuator .
pat:EP0805439_A1#claims_1_16-1_16 rdf:type     ordo:lens .
pat:EP0805439_A1#claims_1_13-1_13 sumo:hasPart pat:EP0805439_A1#claims_1_16-1_16 .
```

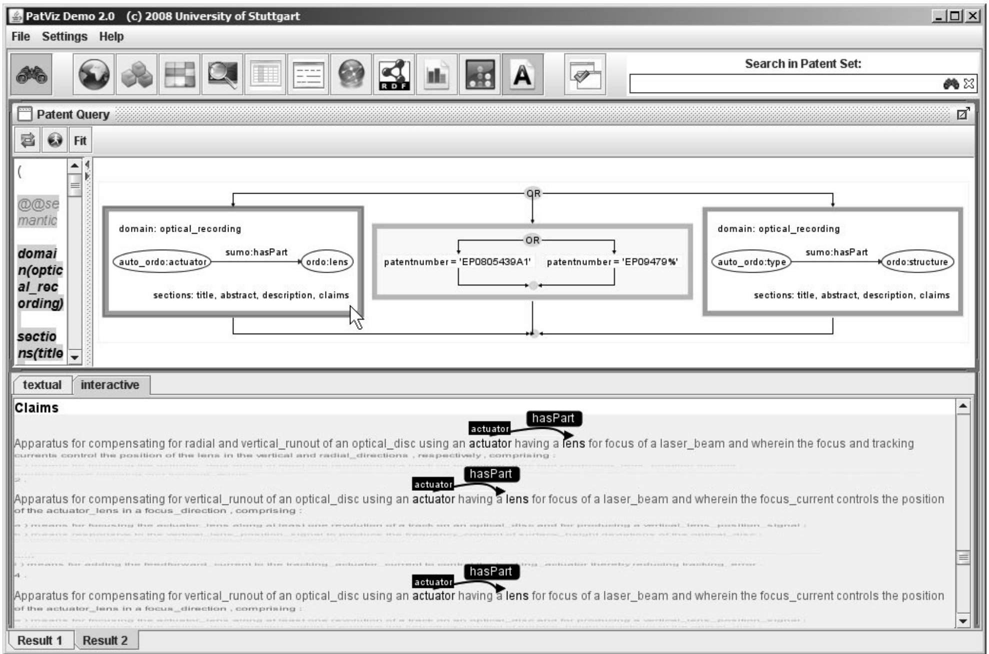

Figure 2: Highlighting of Semantic Search Results and Metadata Structure

5 Discussion and Conclusions

In this paper we have described a focus+context technique for focusing on semantic annotations in large text documents. We have shown an approach to overlay text with the metadata structure of inline annotations. The concepts have been implemented in a prototype for patent documents. In the current version the metadata are extracted in an automatic process and stored separately in a knowledge base. In a mergin step, text and annotations are combined and serve as input to the visual interfaces.

Based on this initial prototype further research has to be done, in particular with respect to user evaluations. Also a more general investigation of the hypothesis that semantically annotated sections are of special interest for users has to be done for other (non-patent) domains. Especially when annotations are done manually and not, as in our case, automatically based on established statistical metrics.

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