

Using Linked Data to Reduce Learning Latency for e-Book Readers

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Abstract. Web 2.0 technologies provide an opportunity to transform learning into a social experience: social learning can directly benefit from user-generated content analysis. The e-book device is an object central to the learning process; it becomes an ideal medium to promote innovative learning tools. In this paper, we describe how we leverage user generated content in e-books, generally in the form of unstructured annotations, to reduce the latency between professor knowledge, book content and student assimilation.

Keywords: Social Learning, Semantic Web, Linked Data, e-Book

1 Introduction

The set of people learning with a given e-book form a de-facto community, which is even more relevant if they are reading at the same time, with the same purpose or during the same activity, e.g. a class. Currently, very few platforms allow social interactions between such people that are dedicated to their reading activity; readers can connect but at a very high level and generally outside the platform (e.g. forums in LibraryThing¹, chatting in Bookglutton² or more general social cataloging features GoodReads³ and Shelfari⁴).

The main problem with these platforms is that interactions cannot be directly linked to the context of reading and thus, do not allow fine-grained interactions about a specific part of the book. Bookglutton goes a step further by letting users chat while reading, but does not exploit the contents and context of annotations in the e-book. This issue was already explored [1] [2], but no solution was proposed based on the semantic analysis of the annotations.

An important observation for our work is the fact that in most cases, annotations in e-books are in the form of short, unstructured textual messages, associated to images, paragraphs or chapters. These can include transcriptions, reformulations, additional comments, questions or explanations (such as student

¹ <http://www.librarything.com/> - visited September 2010

² <http://www.bookglutton.com/> - visited January 2011

³ <http://www.goodreads.com/> - visited October 2010

⁴ <http://www.shelfari.com/> - visited March 2011

annotations in BookGlutton⁵). Clearly, services that leverage these annotations can increase the social dimension of reading. They can help readers determine a common environment to socially learn by seeing others' annotations or to generate interactions between students during a same activity.

In this paper we present our ongoing work on services that leverage semantic technologies and especially Linked Data for providing a social dimension for reading and implicitly, learning.

2 Management of Shared Annotations using Linked Data

Linked Data is an evolving component of the Semantic Web. It can be defined as a community effort to extract or publish data from various sources, interlink it and store it in a semantic web format, such as RDF. The content of these online linked datasets is diverse. It consists mostly of data about people, companies, books, geographic locations, films, music, television and radio programs, information about medicine (genes, proteins, clinical trials) and online communities (statistical data). The most used online dataset is certainly DBPedia[3].

An important source of social knowledge is the set of annotations produced by the user. In our framework, our primary hypothesis is to consider these annotations on a conceptual level. More concretely, this means that we associate each annotation to one or several concepts in a Linked Data source (e.g. DBPedia). There are several reasons to make this association: (i) provide a rich approximation of their meaning, (ii) the capability to retrieve related concepts and category terms, operation that we call semantic expansion⁶ and (iii) the fact that annotations are generally short and that contextual cues are not always available. Therefore, Linked Data sources can enrich the description of such annotations with additional metadata and related concepts.

The association of annotations to concepts in Linked Data is performed by a disambiguation process that leverages the context of the annotation to match it with the most relevant concept in the knowledge base. Each annotation provided by the user is associated to a context, which is constructed from different sources, such as previous annotations shared by the user in the e-book and the set of annotations shared by others that are related to the given paragraph. Parallel to this, a set of candidate concepts are retrieved from DBPedia, that contain the given annotation in their label. The candidate concepts are ranked using cosine similarity between the vector constructed from their abstracts and the contextual cue vector. Once this disambiguation has been performed, the second use of Linked Data is the expansion of the concept by exploring both its semantic neighborhood and hierarchical links.

⁵ e.g. <http://www.bookglutton.com/glutton/melissthangx0x0/14459>

⁶ As an example, here is the semantic expansion of the annotation "Facebook": [Global Internet Community, Student Culture, Social Information Processing, Social Networking Service, Social Media, Web 2.0, Internet Technologies]

3 Easy Social Navigation with Heatmaps

Key to the exploitation of Linked Data results in social learning is the way the user will perceive the analysis results and whether it will be useful or not. In [1], Jae K. Kim et al. describe how they let students place symbolic evaluations as annotations, and then graphically represent the synthesis of these annotations as colors in the e-book, thus enabling what is called **Social Navigation**. We follow the same investigation track, but instead of focusing on design choices and symbolic evaluations, we analyze free text annotations using Semantic Web techniques.

The user, a learning reader (our target is post-graduate students), opens an e-book and states their interest using freely chosen keywords; the keywords express their goal for the reading session. The keyword is semantically analyzed and a global similarity computation is run on the annotations of the book. Each annotation is attributed a heat value based on its relevance to the user's goal in reading the book. The appearance of the book is modified to display in a colored way the zones where the annotations are the most heated.

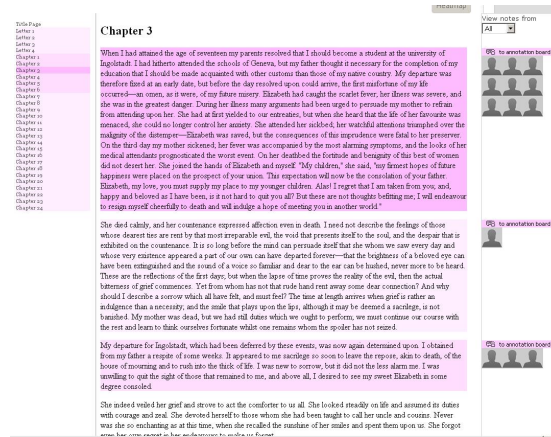
Figure 1(a) presents an example of the heatmap feature. This was produced by our prototype of the sBook [4] using data gathered from annotations from BookGlutton (229 annotations by 39 different users on the e-book "Frankenstein" by Mary Shelley).

The choice was made to use the paragraph as the finest precision of annotation heat. The heat of a paragraph is the total sum of the heat of each annotation on the paragraph. Note that the heatmap is a navigation indication for the user, it is not meant to be the final step for a learning reader; it is completed by the display of authors of annotations (on the right-hand panel) and the use of what we call annotation boards: these are separate windows that browse through all the annotations of a paragraph and the comments inspired by these annotations. The annotation board is where the user may find valuable information and participate in discussions.

The choice of the algorithm for heating an annotation is the focus of our current research. Figure 1(b) presents the administration interface that enables to choose different implementations for the user to experiment with. Annotations are heated based on their proximity to the resulting vector of words. We currently implement three expansion methods:

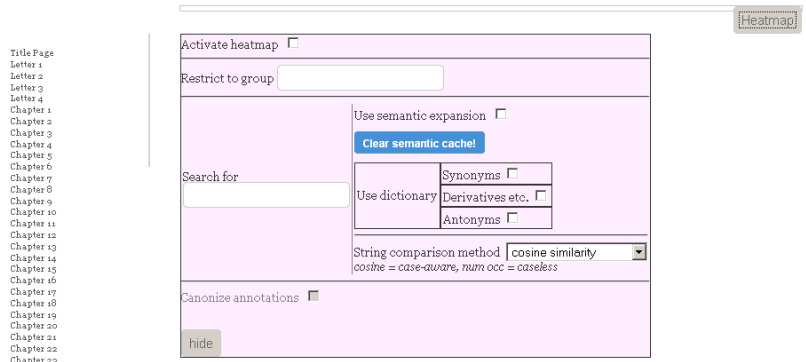
- no expansion, we simply search for the keyword
- a dictionary-based heatmap, that may take into account synonyms, antonyms and derived words (e.g. adjectives for a noun)
- a Linked-Data-based heatmap, that takes into account the expansion of the search keyword as described in the present paper.

Our first experiments show that named entities (e.g. "Paris") are best expanded using Linked Data, while literary theory terms (e.g. "poetry", "characterization") are best expanded using dictionary techniques. This is why we keep both options open and also separate, so as to validate their usefulness with user experimentation.



(a) sBook with Heatmap activated (overview)

Frankenstein, by Mary Wollstonecraft Shelley



(b) Administration Heatmap Configuration

Fig. 1. Heatmap screenshots

In a first step the annotations are processed as text; currently being implemented, we first process each annotation by associating it to a cluster of tags, obtained by semantic evaluation techniques. The similarity measure will be computed between the cluster of tags of the annotation and the vector of words expanded from the user keyword.

It may be noted that, while we explore keyword-based heatmaps, we also intend to explore other options: time-based heatmap, where the heat of an annotation is related to its creation date; location-based heatmap, taking into account the location of the annotation's author; or more generally context-based and activity-based heatmaps (which present intersections). These will be used for further user experimentations, first to compare their effectiveness with keyword-based heatmaps, second because they are relevant to our general research on the link between the digital and physical worlds.

4 User Interaction Profiles

Each user in the collaborative learning environment associated to the e-book is represented by an interaction profile, constructed from their shared annotations in the system. The objective of the interaction profile is to provide a digital representation of the user's expertise. Each concept in the profile can be manually annotated by users. More specifically, we propose an interactive tool for users to declare their level of expertise and to choose how much of this expertise to share in different social spheres and situations (Figure 2).

Thus, a user can for example say that they have high expertise in "European Union Member States" but that they wish to share this expertise only with classmates and teachers and that they are ready to interact on this topic only when they are at the library or at school. With the help of DBPedia, we also retrieve the hierarchical tree associated to the concept, which allows the user to share the same concept with other social spheres, but with less granularity. In this way, the user can share different levels of granularity about the same knowledge with multiple social spheres (e.g. detailed knowledge for the class, less detailed for friends).

Linked Data allows to retrieve the hierarchical tree and semantic neighborhood associated to a given concept. In the case of collaborative learning, we leverage this feature by offering users a more granular way of sharing their interaction profile, constructed from the shared annotations. Such interaction profiles make it possible for the system to select the right person to ask a question on a specific topic. In order to overcome the problem of data sparsity in case of new members in such learning communities, we are currently investigating the possibility to connect this service to other Social Platforms and to build a user interaction profile from annotations shared in them. In this way, the user will be recommended people to interact with even if they did not share sufficient annotations. More specifically, each time the user opens the e-book, they will be presented with the most relevant readers to interact with, based on complementary expertise in specific topics of interest and declared sharing preferences related to that topic. This provides students with a seamless way of linking to co-learners and thus form spontaneous learning communities on a specific part of a lecture.

5 Conclusion

In this paper we have presented our research, which focuses on integrating Linked Data results into e-book navigation tools for students in order to enhance social learning. We base our work on user annotations, we process these annotations with Linked Data technologies, we use the produced synthesized results to modify our e-book display; we hope to maximize reading and learning efficiency, to create common environments and implicitly, communication opportunities. At the basis of our innovation is the hypothesis that the huge amount of shared content in different Social Platforms offers exciting opportunities to enrich the learning



Fig. 2. Interaction Profile Declaration Tool

experience and reduce the knowledge latency in the class, which we define as the delay between the encoding of the knowledge of a professor on a specific subject into information (e.g. a lecture or slides) and the assimilation of this information as knowledge by students.

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⁷ Cambridge University - <http://www.cambridge.org/press/article.asp?artid=154961>