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An ontologically enhanced metadata editor

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Abstract

This paper focuses on the problem of metadata tagging for existing documents. It introduces a novel approach to the problem by providing an interface, Metasaur, that supports an exploratory view of the domain vocabulary. It also suggests the use of metadata tagging as a learning tool in online educational systems. It reports a qualitative evaluation of Metasaur for creating metadata terms describing the content of learning objects.

Keywords document management, hypermedia, learning object metadata, metadata, ontologies, visualisation.

1 Introduction

The W3C Metadata Activity Statement [1] defines metadata as information about information. It is important to have well crafted metadata in order to provide dynamic optimisation, flexibility and integration of distributed heterogeneous information [2]. In addition to these, metadata also plays an important role in providing benefit to end-user cognition.

Metadata tagging is a problem, especially in systems with many existing documents and a large metadata term vocabulary [3]. There are several existing tools available. For example, one such tool, Annotea [4] builds on semantic web technologies. The task of annotating existing documents with metadata is challenging and non-trivial because it is hard to be thorough and consistent, and the task is both demanding and boring. It would be a tedious task to add the metadata by hand. An automated approach is preferable, but to ensure the metadata is of suitable quality, a user would still be required to verify and possibly enhance the set of terms identified automatically.

We are particularly interested in an interface that not only allows for easy tagging of existing

documents, but also to enhance end user cognition for both verifying terms that have been automatically added and ones the user wishes to manually add. The interface should be able to show not only synonymous terms, but also other relationships such as hierarchical or antonymous ones. This may help the user clarify their understanding of the terms available for metadata markup.

As an initial vocabulary, our approach uses an existing glossary source. We have been exploring ways to automatically construct an ontology from existing documents and, in particular, from existing glossary sources. The ontology is an essential part of a visualisation tool that assists users in exploring domains with hundreds of concepts. We take a broad interpretation of an ontology as an explicit specification of a conceptualization [5]. The ontology establishes semantic relationships between the terms in the glossary. It is envisioned that these relationships will help enhance user cognition to infer new terms to add from the contents of the document. Although ontologies have the potential to be very useful, they are generally difficult and time-consuming to construct manually. There is considerable appeal in finding ways to automate the process [6].

One area where metadata has an important potential role is in tagging learning objects in an educational domain. There are many situations where it is important to create metadata defining the concepts associated with a learning object, for example, to provide efficient searching and selection of materials for different types or learners. There is also potential to use the editor as a learning tool to make e-learning from passive lecture materials more active. For example, the learner marks up the core elements in a slide or audio lecture themselves and can compare this against the components marked up by the instructors or other students. Results from this could feed into user models that try to represent learner knowledge and adapt material to suit the user's skill level.

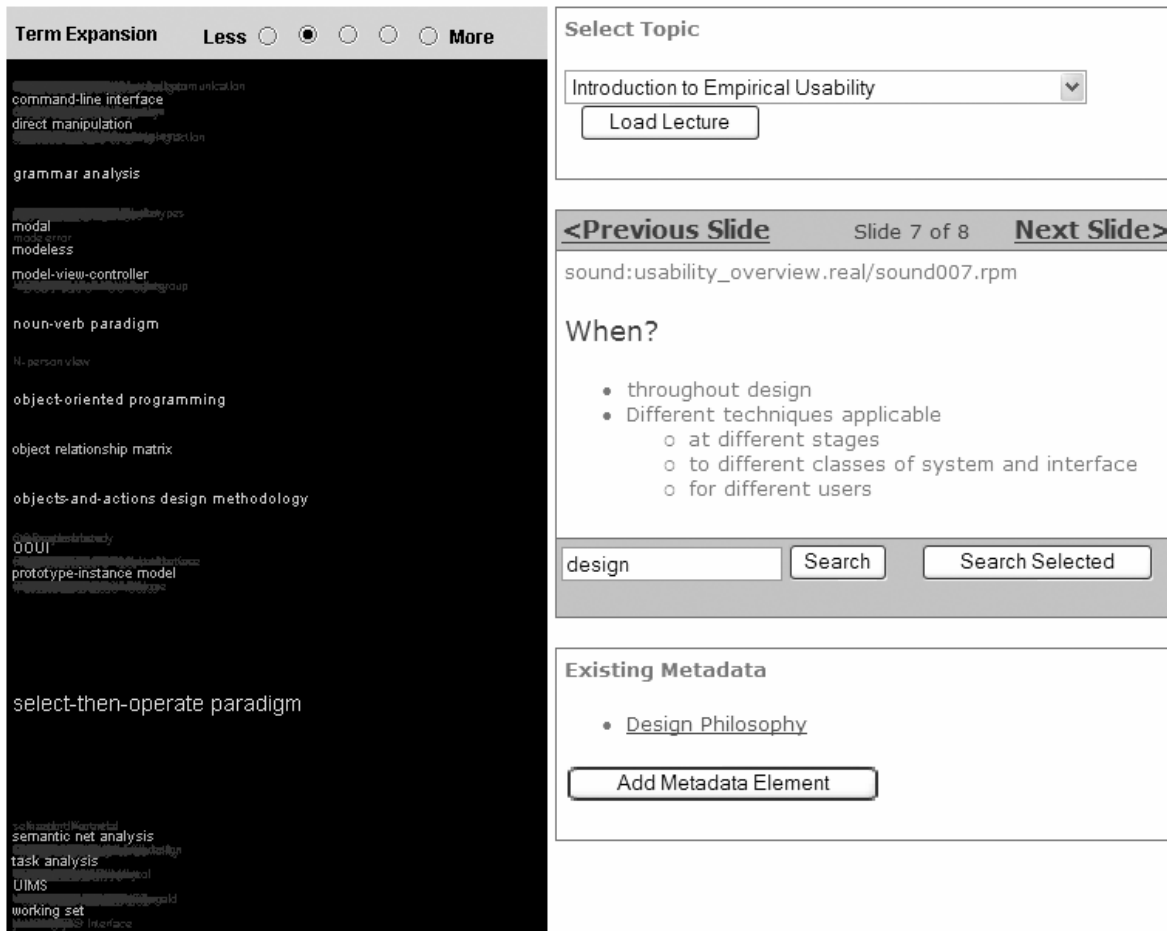


Figure 1: The Metasaur interface showing the SIV interface on the left, and the slide with associated metadata on the right. The SIV interface currently has the term *select-then-operate paradigm* in focus with related terms such as *noun-verb paradigm* and *objects-and-actions design methodology* are shown as a secondary focus. Note: this image and subsequent ones have been rendered in black and white for publication clarity.

This paper provides a description of the Metasaur interface for metadata markup and its underlying ontology, followed by exploratory evaluation with discussion, and finally conclusions and future work.

2 Metasaur

The prototype metadata editor we have developed is called MetaSaur. It makes use of the visualisation Scrutable Inference Viewer (SIV) for its navigation. SIV is an evolution of VIUM (for Visulisation of Larger User Models), a tool that can effectively display large user models in web-based systems [7]. VIUM is inspired by the work by Murtagh on his Automatist StorytellerSystem [8].

From the user's point of view at the interface level, SIV is essentially unchanged from VIUM except for the removal of widgets from the applet display. These controls have been embedded in the HTML instead and communicate to the SIV applet through JavaScript. The HTML for the website is generated

from Python CGI scripts. Figure 1 shows a screenshot of Metasaur. The SIV visualisation of the ontology is displayed on the left, and the contents and control widgets are on the right. The content of each slide currently consists of the slide itself, an audio object associated with the slide, and questions related to the concepts.

As an example of adding metadata to a learning object, a user Tanya wishes to annotate the slide shown in Figure 2. She reads the bullet point "Observation of natural use" and highlights the word *observation*, then clicks on the **Search Selected** button to perform the search. Results are shown on the visualisation on the left hand side of the interface. Tanya now scans through the search results, deciding that the term *observational study* is appropriate to describe the slide. She selects *obversational study* in the visualisation, and clicks on the **Add Metadata Element** button. A popup asks for confirmation before the term is associated with the slide (Figure 3). The term is added to the slide (Figure 4), and now Tanya scans the other visible terms on the

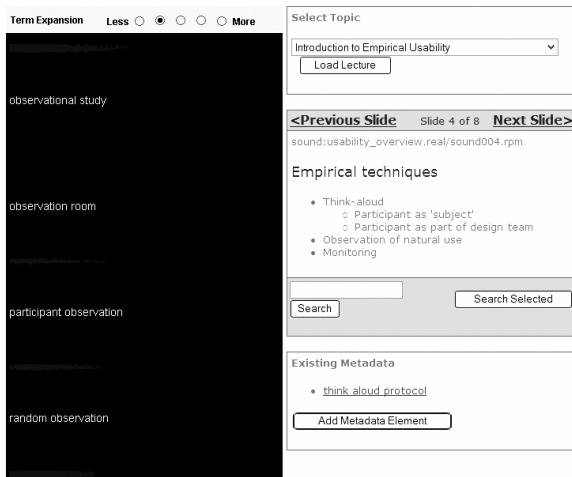


Figure 2: User wishes to add metadata terms to the slide labeled *Empirical techniques*. She does a search for the word *obvseration*, the resulting matches are shown on the visualisation.

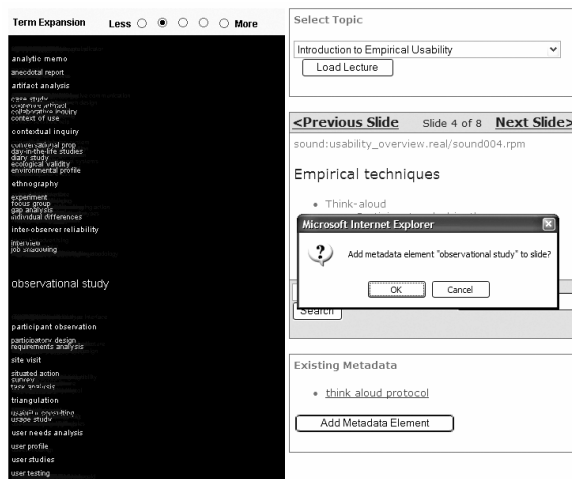


Figure 3: User selects the term *observational study* on the visualisation and clicks on **Add Metadata Element** to add the term to the slide.

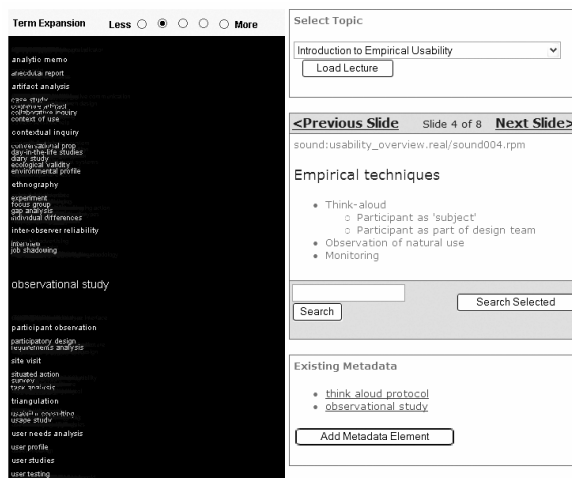


Figure 4: Screenshot after the term *observational study* has been added to the slide metadata.

visualisation to see what else might be appropriate to describe the slide. She sees the term *ethnography* and selects it (Figure 5). The term is then added the same way as the previous one (Figures 6 and 7).

The concepts in the ontology are displayed in a vertical listing. It utilises perspective distortion to enable users to navigate the user model. At any point in time, the concept with the largest font is the one currently selected. A subgraph is created encompassing this term and those that are deemed related. Concepts connected directly to the selected concept are put into a secondary focus, appearing in a larger font size, spacing and brightness than those further away in the ontology. Similarly, concepts at lower levels in the tree are shown in progressively smaller fonts, less spacing and lower brightness. Concepts that are not relevant are bunched together in a small dimmed font. Users can navigate through the ontology by clicking on a concept to select it. The display changes so that the newly selected concept becomes the focus (see Figure 5 for an example). A slider allows users to limit the spanning tree algorithm to the selected depth. This effectively changes the number of visible terms. In Figure 1, for example, the main focus is *select-then-operate* paradigm. Some secondary terms are *noun-verb paradigm* and *objects-and-actions design methodology* and the depth is set at 2. Changing the depth will change the number of visible terms on the visualisation.

We envisaged that the SIV interface would guide the navigation for users adding metadata. The converse is also true; contents of the slide can be used to guide the navigation of the ontology. This is achieved through the use of Javascript to allow users to select text in the slide contents, and clicking Search Selected, allowing rapid searching of terms in the contents. A demonstration version of Metasaur is available online¹.

3 Underlying Ontology

The MECUREO tool is used for automatic generation of an ontology [9]. It parses semi-structured dictionary and glossaries to create an ontology. The word and definition tuples in the dictionary are parsed to create a digraph of keywords linked to related keywords that appear in the definition. Grammatical conventions in the definition are used to add typing to the links. A point query can be executed from a term in the ontology. A spanning tree from this point is created. MECUREO also provides facilities to merge point queries into single subgraphs.

An important feature of MECUREO is that it allows a user to scrutinise the relationships between the words in the graph. It does this by linking each

¹ http://www.it.usyd.edu.au/~alum/demos/metasaur_hci/



Figure 5: The user has *observational study* in focus, and sees the related term *ethnography* (above left). The user clicks on *ethnography* to bring it into focus (above right).

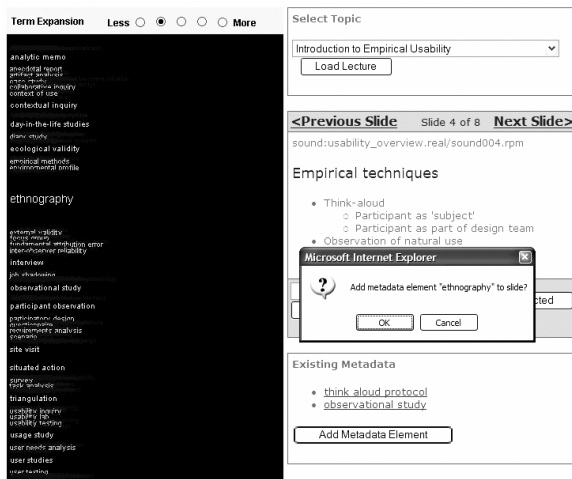


Figure 6: The user decides to add the term *ethnography* as it is related to the material on the slide.

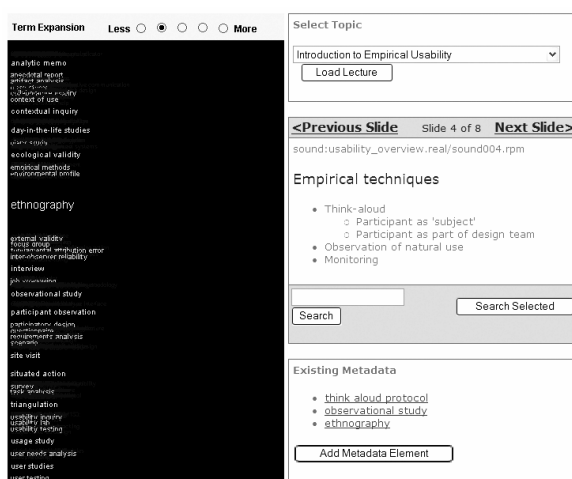


Figure 7: The slide with the metadata terms *think aloud protocol*, *observational study*, and *ethnography* added to it.

term back to the original dictionary definition. In theory the definition should make it easy for a user to infer why links exist.

We have used MECUREO to build ontologies from the Usability First glossary of HCI². The process results in an ontology in the HCI domain consisting of 1125 terms and 5920 directed relationships between them. The ontologies can be exported as an OWL file (W3C, 2003). Metasaur only requires the URI of the OWL file generated by MECUREO as input for the visualisation.

4 Evaluation

An evaluation was performed involving seven participants. The goal of the evaluation was to get some initial feedback on the effectiveness of the interface and a better understanding of the way that users would interact with it. Our hypothesis is that users will make use of the visualisation to add terms that are not explicitly in the document they are annotating.

The participants were asked to annotate a single set of lecture slides about an *Introduction to empirical usability*. The participants had to read each of the slides in the lecture, and then choose the concept usability. The participants had to read each of the from the list of terms in the visualisation that best describe what the slide was about. The following was read aloud to each participant, with references to the interface for each particular element described:

Task: *annotate the lecture slides with metadata terms. Choose terms that best describe the slide from the glossary. If you can't find any, then just go to the next slide. There are only 8 slides, the first slide is the is the title.*

A Glossary has been provided on the left hand frame to help you.

You can search the glossary from the search form on the right.

You can select some text on the slide and click "Search Selected" to search as well.

The display on the left shows a list of terms you can add. You can select a term by clicking on it. Related terms are shown in progressively larger fonts.

You can increase or decrease the number of terms on the display using the depth slider.

² <http://www.usabilityfirst.com>

Summary of Experiment Logs

Subject	No. Terms	Total Time (min)	No. Clicks	No. Back	No. Search	No. Depth	Click Conversions
A	13	10.77	3	4	34	1	0
B	16	11.88	0	0	38	6	0
C	19	20.85	8	1	55	11	0
D	32	26.07	12	9	42	4	2
E	11	17.63	1	0	26	1	0
F	43	34.37	20	0	84	3	2
G	36	22.85	15	2	55	0	3

Table 1: Results from evaluation showing the number of terms the user added, the time to annotate all the slides, the amount of clicks (on terms in the visualisation, on the back button, on the search button, and the depth buttons), and also the number of ‘click conversions’ – terms added which were discovered not through a direct search but by navigating the ontology.

When you find a term you want to add, click the term labelled “Add Metadata Element”.

Click “finish” down the bottom when you are done.

Monitoring and logging was used to collect click streams. The quantitative results from the evaluation are shown in table 1.

In the case of the first user, they took nearly 11 minutes to annotate all the slides. A total of 13 metadata terms were added. 34 searches were made (by either typing in a term and clicking on the button or by highlighting text on the slide and using **Search Selected**), and back was pressed 4 times to backtrack through the terms they had selected in the visualisation. The user clicked on a total of 3 terms on the SIV display (not including search results) and the final column, Click Conversions, shows they added no terms from these clicks. From the seven participants, B, D and E had previously used the interface. The participants B, D, F and G had a familiarity with the domain, and user D was in fact the author of the slides.

Empirical techniques

- Think-aloud
 - Participant as 'subject'
 - Participant as part of design team
- Observation of natural use
- Monitoring

Figure 8: The contents of slides 4 that the participants were asked to mark up in the experiment.

What is usability?

"all aspects of an activity's performance that can be affected by the use of technology" (N&L:30)

- speed of performance
- incidence of errors

Figure 9: The contents of slide 5 that the participants were asked to mark up in the experiment.

An analysis of the terms added to each of the slides was also carried out. The contents of slides 4 and 5 are shown below (Figures 8 and 9).

The terms added by the participants have been tabulated in Tables 2 and 3. The results in the tables have been divided into three sections – white for terms that appear on the slide, grey for terms that are a near match terms on the slide, and dark grey for terms not on the slide. Users who are familiar with the domain have their terms designated with a *, those who were not are designated with a x. For example, on slide 5, the term *speed* appears in the first bullet point of the slide, and so the row is coloured white in the results. The term *speed-accuracy tradeoff* does not appear on the slide but is a concept that the slide teaches. Thus this term appears in the dark grey column of the results. In slide 4, the bullet point “Observation of natural use” is synonymous to the term *observational study* – a near match to what is written on the slide so has been shown in grey on the table.

Slide 4	A	B	C	D	E	F	G
think aloud protocol		*		*		*	*
Empirical Methods	x		x		x	*	
observational study	x						*
Empirical methods		*	x				*
participant observation		*				*	*
observational study				*		*	*
participatory design				*		*	
Software monitor				*			*
user studies				*			
ethnography				*			
time-stamping				*			

Table 2: terms added by users for slide 4 (refer to figure 8).

Slide 5	A	B	C	D	E	F	G
Speed		X				*	*
Error				*		*	*
Errors		X					
Usability					x	*	*
performance measure			x	*		*	*
critical incident analysis							*
effectiveness						*	
Usability Evaluation			x	*			
Task completion time				*			
Empirical methods			x				
usability metrics	x						
speed-accuracy tradeoff		x				*	*
usability evaluation	x						

Table 3: terms added by users for slide 4 (refer to figure 8).

5 Discussion

The task our participants performed is akin to that of a librarian cataloguing a book. In both cases, the participants or librarians is not reading the whole book (or listening to the audio on the slide).

All participants made extensive use of the text searching facilities and added a reasonable number of terms. However, one identifiable problem was that not all the participants were familiar with the domain, and were hesitant to add words when they did not understand the exact meaning (even if it was a word on the slide),

The results show that only three users (D, F, and G) made use of the exploratory design of the visualisation to find new terms (the Click Conversions column in Table 1). They represent three of the four users who were familiar with the user interface design and programming domain. These three users also tended to add more

metadata terms than the other participants. This suggests that the other users needed either more time to gain familiarity with the interface, and also a better understanding of the domain and task.

When the participants could not find terms in the vocabulary that directly appeared on the slide, they had to rely on their understanding of the domain to infer what the slide was about. Table 2 shows the users who understood the domain tended to add more near match terms to the slide compared to the other users. Table 3 shows that even when there were terms that were direct matches to those in the glossary, the same users seemed more confident to add these terms to the slide and discover more terms to add through the visualisation. We hypothesise that given just the glossary website, these users would not have discovered as many metadata terms as they did with Metasaur.

The next stage in our research is to refine the interface with easy access to the actual glossary definitions to help aid users in clarifying their understanding of the domain. We plan to incorporate the dictionary definition as a popup when users right click on the terms in the visualisation. Although users could do a manual search of the original Usability First HCI glossary in a separate browser window, this would have been cumbersome and time consuming.

We then propose to do a more complete evaluation with users listening to the audio available for these slides. In this case, the user will hear additional terms that are not on the slides as well as gain a clearer sense of the learning objects of the full slide with audio.

We also propose to do some experiments in the metadata verification by providing users with marked up documents and asking them to check the markup, aided by both the SIV display and the glossary available in conjunction with it.

6 Conclusions

We have described a tool that supports users to annotate existing documents with metadata. The visualisation allows users to explore the terms in the domain and aids cognition for adding and verifying metadata. The exploratory nature of the visualisation is most suited to users who are familiar with the domain.

There is promise in the use of such visualisations to aid users who have to annotate existing data with metadata. The growing interest in the semantic web means that ontologies will continue to play an increasing role in metadata creation, and tools such as Metasaur can harness their potential to make the task of metadata annotation easier.

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