Visual Topic Maps Layer between Document Collections and Learning Material

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ABSTRACT
This paper introduces a semantic layer, called visual topic maps, to build a bridge between annotated document collections and the use of these documents as learning material. The main components of a visual classification are metadata-based topic maps attached to documents that allow customization according to users’ needs and profiles. The metadata of documents and visual topic maps are based on MPEG7 and its Semantic Descriptor including additional attributes on instructional information. These generic metadata are complemented by domain specific metadata based on the domain of the document collection. The paper explains the visual topic maps concept and sets it in context to research on learning objects, metadata and educational modeling languages. The structure of visual topic maps and their metadata are then discussed in more detail and the process of building visual topic maps and using them is outlined.

Categories and Subject Descriptors
H.4 [Information Systems Applications]: Miscellaneous;
I.7.5 [Document Capture]: Document analysis

General Terms
Management, Standardization

Keywords
Visual Semantic, Visual Topic Maps, ISO standard

1. INTRODUCTION
The context for the research presented in this paper is the "Memory of the Past" project being carried out at the National Institute of Informatics, Japan. This project aims at collaborative building of a multi-lingual multi-cultural digital memory of the past by school pupils, teachers and multi-disciplinary experts. A wide variety of techniques are employed to present the history: ancient maps and drawings are digitized, 3D animations of artefacts are constructed, historical documents are analyzed, images and videos are recorded to show the present condition of historical sites, etc. The resulting document collection needs to be semantically enriched and annotated using metadata to facilitate the searching for documents. Currently, the documents are being annotated using standardized metadata schemes like Dublin Core\(^1\) and LOM (2002)\(^2\) and partly with specifically developed metadata schemes such as the ontology-based metadata schemes developed in [10]. From the perspective of eLearning, a project such as the "Memory of the Past" project delivers a very large archive of potential learning objects. The challenge that each individual teacher faces is to locate the appropriate information using a semantic search engine. This task is compounded by several factors: the sheer number of documents of various types and content, the distribution of documents and their metadata across multiple sites, the limitations of standardized metadata, the lack of context for standardized metadata, the restrictions in time available to 'surf' and search for resources, the variety of languages connected with such a project, or possibly the lack of domain knowledge in highly specialized areas. The research presented in this paper aims to address some of the issues mentioned to facilitate access to information in contexts of very large collections of documents relating to a common subject area as given in the example of the "Memory of the Past" project. The idea is to introduce a semantically rich layer, informally called 'visual topic maps', between document collection and learning material that links documents according to topics. One motivation behind this approach is to add a more focused, semantic layer on top of the untargeted metadata that are commonly used to describe single documents. Speaking from an eLearning context, the visual topic maps build on learning objects and become information sources and building blocks for stories and learning material. The implementation and practice have been done using a semantic extension of TM4L\(^3\) as TM4L is one of the most popular topic maps editors currently available. In the following of the paper, Section 2 outlines the background of "Visual Topic Maps" and a discussion emphasizes the thinking behind the concept that is explained in its main aspects thereafter. Then,

\(^{1}\)Dublin Core http://dublincore.org
\(^{2}\)IEEE Learning Technology Standards Committee (LTSC) http://ltsc.ieee.org/wg12

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topic map implementation is introduced in Section 3, followed by section 4 on authoring and use of topic maps. A summary and plans for future research conclude the paper in section 5.

2. WHY VISUAL TOPICS?

Visual Topics are a form of semantic where the knowledge base is driven by visual features. These characteristics support our idea of providing an interpretive, semantic layer on top of document collections that classifies these documents according to scope, context and constraints. The terms 'visual topic' further matches well the call for 'subjective topic' or 'subjective meta' data which we will outline in later sections of this paper. Regarding the learners [11], visual topic maps provide support for an efficient context-based retrieval of learning resources [1] as textual topics have semantic limitation compared to visual topics which have a better awareness in topic-domain browsing using a higher semantic level. Furthermore, other advantages are related to information visualization; customized views, adaptive guidance, and context-based feedbacks. Regarding the instructors, visual topic maps improve the effectiveness of management and the maintenance of knowledge and information according to several layers [3]. It provides a better personalized courseware presentations using visual semantics. It can help distributed courseware development, to reuse and exchange of learning materials. Finally, it is possible to set collaborative visual topic maps authoring as it has been shown in [4].

3. TOPIC MAPS MODEL

The Topic Maps model is defined by a resource algebra to handle topic maps produced by semantic computing approach such as Latent Semantic Analysis [2]. The resource algebra is described in the following of this section.

Resource Algebra: This Resource algebra uses resources’ domain data types. Resource semantic type and functions in the topic maps are directly represented using the appropriate data type and functions supported by the resource algebra. This algebra follows two targets. First, it is the semantic interface between scientist to reduce the semantic gap and to strength the metadata bridging between them. Second, this high level semantic algebra facilitates the collaborative intersection of scientists using topic maps integrating high level semantics. Let us remind the notion of many sorted algebra [6]. Such an algebra consists of several sets of values and a set of operations (functions) between these sets. It consists of two sets of symbols called sorts (e.g. topic, pdf, rtf, jpeg) and operators (e.g. tm_transcribe, semantic_similarity); the function sections constitute the signature of the algebra. Second Order Signature [7] is based on two coupled many-sorted signatures where the top-level signature provides kinds (set of types) as sorts (e.g. DATA, RESOURCE, SEMANTIC,DATA) and type constructors as operators (e.g. set).

To illustrate the approach, we assume the following simplified many-sorted algebra as topic map model implementation:

<table>
<thead>
<tr>
<th>Kinds</th>
<th>DATA, RESOURCE, SEMANTIC_DATA, TOPIC_MAPS, SET;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type Constructor</td>
<td>← DATA topic;</td>
</tr>
<tr>
<td>← RESOURCE pdf, rtf, htm, xml, cvs, jpeg, tiff;</td>
<td></td>
</tr>
<tr>
<td>← SEMANTIC_DATA bi_sm, mpeg7_sm;</td>
<td></td>
</tr>
<tr>
<td>← SEMANTIC_DATA 5w1h_sm;</td>
<td></td>
</tr>
<tr>
<td>← TOPIC_MAPS tm(topic maps);</td>
<td></td>
</tr>
<tr>
<td>← TOPIC_MAPS → SET set;</td>
<td></td>
</tr>
</tbody>
</table>

Unary operations
∀ Resource in RESOURCE, resource → sm:
SEMANTIC_DATA, tm tm_transcribe;
∀ sm in SEMANTIC_DATA sm set(tm) → semantic_similarity;

Binary operations
∀ tm in TOPIC_MAPS, (tm)→ → tm topicmaps_merging;
∀ sm in SEMANTIC_DATA , ∀ tm in TOPIC_MAPS, sm, tm → tm semantic_merging;
∀ topic in DATA, ∀ tm in TOPIC_MAPS,
set(tm) x (topic → bool) → set(tm ) select;

The notion sm:SEMANTIC_DATA means "some type sm in SEMANTIC_DATA." So there is a typing mapping associated with the tm_transcribe operator. Each operator determines the result type within the kind of SEMANTIC_DATA, depending on the given operand resource types. The semantic merging operation takes two or more operands that are all topic maps values. The select takes an operand type set (tm) and a predicate of type topic and returns a subset of the operand set fulfilling the predicate. From the implementation of view, the resource algebra is an extensible library package providing a collection of resource data types and operations for domain-oriented resource computation (e.g. agriculture field [8]). The major research challenge will be the formalization and the standardization of cultural resource data types and semantic operations through ISO standardization.

Representation of Topic Maps: A Topic Maps can be represented as a triple G = (T, r, g) where T is the set of topics, G is the graph representation of T, and r is a function called "representation function". The domain of r is a part of G. The range of r is T. A topic is defined by a name, by properties links to learning resources and by metadata. The name is textual data, on what the author can write. The author can use the narrative to tell facts, provide interpretations, make comparisons, draw attention or similar. The narratives of stories are structured into units and paragraphs. Within a unit a line of argument will be preserved. Units can be used to tell different aspects of a story.

Definition: A visual topic map is a topic map where the type of topic name is not only a string but a pointer to a multimedia object. a topics are visual topics. The semantic vectors related to resources are associated to each topic. Furthermore, links to learning object resources are visual topic’s resources. The purpose of these links is to relate the visual topic closely to the underlying documents using some knowledge management systems or ontologies [9]. The documents can provide examples, illustration, proof, further explanation, additional material or similar.
4. AUTHORING AND USING "VISUAL TOPIC MAPS"

The concept of Visual Topic Maps was introduced in the context of the "Memory of the Past" project to enable organizing, maintaining, and using very large repositories of digitized images. The project’s ambitious goal to build a rich, multi-lingual, multi-cultural digital memory of the past by users with different nationality, background, and level of expertise posed a number of requirements to the authoring environment of visual semantics, which was designed as an extension of the Topic Map Editor TM4L, which supports visual topic maps. These requirements include implementing the user interface in various languages, enabling handling of visual topics, supporting the author in building a visual topic map, etc. It includes the full functionality of TM4L complemented with new features for supporting the creation and use of visual topic maps.

4.1 User interface internationalization

The user interface has been implemented currently in more than 12 languages including English, Spanish, German, French, Traditional and Simplified Chinese, Japanese, Nepali and Thai language. While internalization of a website or a tool with simple interface is straightforward using the Java internationalization feature as it is shown in Figure 1, the complication in the case of this application comes from the translation of the predefined in English object types, which are used in a special way in the application, for example, the predefined basic relationship types 'class-subclass', 'part-whole', and 'instance-of', which are used for building the topic hierarchy in the Topics panel.

4.2 Handling visual topics

A visual topic map contains two types of topics - 'standard' topics and 'visual' topics. Visual topics represent concepts as images. Thus a visual topic presents a repository image and has the image file name as its primary name and a resource of type 'File Path' containing the path of the image file. In this way the primary topic name is not related to any specific natural language. The term for the concept reified by that topic, translated in different languages can be added as additional topic names, scoped with the corresponding language topic. The use of scopes allows displaying only the names scoped with a theme specified by the user when visualizing the topic map. Thus concept names can be displayed in different languages by specifying different scopes. Among the implemented additions in TM4L is the treatment of topic names and resources. In addition to the two resource types defined in the Topic Map standard - internal resources that contain text included directly in the topic map and external resources that specify URLs of web resource, we have introduced a third type, different from both of them. It resembles the external resources in that it is not included in the TM and is specified by its address, which however is not a URL, but a path of a file residing on the local machine where TM4L is installed. The type of the file is one of: JPEG, GIF, or PNG. Topics represent concepts. In a conventional topic map, a concept is reified with a topic, which is named with the term that is used to name the concept. In a visual topic map, a concept is reified with an image, which is reified with a topic having as a name the name of the image file. Since a file name often doesn’t reveal the semantics of the concept (image), it is very important for the topic map authoring that the tool provides a mean for displaying the image. Thus in TM4L, topic name information is displayed differently for the standard and visual topics. If a topic is a standard topic, then the topic name string is displayed; if it is a visual topic, then in addition to the name, the image represented by the topic is displayed (see Figure 2). This way by seeing the image, the author can identify the concept and subsequently add additional name and/or annotate it.

Similarly, in the visualization of the topic map, for all 'standard' topics, their topic names are displayed; for the visual topics - icons of the images that they represent are displayed. For each icon, the corresponding full-size image can be displayed if the "View image" option of the context-sensitive menu is selected. (See Figure 3).

4.3 Support in building visual topic maps

As it was already mentioned, the concept of visual topic maps was introduced to facilitate the structuring and use of large collections of images. Since the visual topics are represented in the topic map by the paths of the corresponding
the creation of such a map is a time-consuming and unpleasant work for the author. From another side, such a presentation allows an automatic extraction of (a draft) of the topic map. In implementing this functionality we took in consideration the fact that in many cases images are already classified in subdirectories with meaningful names (indicating the scope of the stored there images). Thus, in order to support the author, we implemented an automatic creation of a draft topic map by recursive extraction of the structure of a specified file directory, containing image files organized hierarchically in subdirectories. Figure 4 displays the dialog for extracting topics from a file directory. The author specifies the directory, the name of the relationship type to be used in building the topic hierarchy and the root topic to which the extracted hierarchy should be attached. The extracted topics are added to the current (a newly created or an opened) topic map and after its reloading are displayed in the Topic panel (see Figure 5).

The author can then use this draft map as a starting point to produce the desired map. For example, he can delete unwanted topics, restructure the topics hierarchy (by adding/deleting parent topics), annotate topics, create new relationships between topics. Figure 6 shows the visualization of the automatically extracted topic map from Figure 5.

5. CONCLUSIONS

The "Visual Topic Maps" concept introduces a new semantic layer between collections of learning objects and learning material. The topics link semantically related learning objects. As learning objects by definition are not restricted in size the links from the visual topic maps refer to specific topics within the learning objects to guide the reader precisely to relevant sections. Furthermore, visual topic maps provide the context and scope that are required for the specification and use of metadata. The visual topic maps descriptions can be seen as rich metadata that annotate the referred learning objects. Visual topic maps specific metadata and domain specific metadata allow for the customization of topic maps according to the needs and scope of individual users. The Vi-
Figure 6: Visualization of the automatically extracted topic map

Visual topic maps themselves form new learning objects that provide annotation to thematically linked learning objects stemming from large document collections. The metadata of visual topic maps are based on MPEG7 for the links to the multimedia document of the referenced learning objects and on the MPEG7 Semantic Descriptor for each node of the topic map. These metadata are complemented by attributes for instructional information and story semantics. We envisage that the stories will be written by domain experts and used by teachers. The term “Visual” was chosen to express the desire to communicate via a medium, the visual, that is familiar to everyone as there and therefore can be easily authored and easily understood. The visual topic maps provide the mechanism required expressing knowledge and interpretations in a natural way, the visual topic maps metadata deliver the precision for search and retrieval both of top-ics and underlaying documents. The visual topics concept aims at classifying large document collections like they are provided by the “Memory of the past” project for the preservation of the knowledge and culture. Work is currently undertaken to specify multi-dimensional metadata under topic maps model and to collect related data from experts and pupils. The next step will be for experts and non-experts such pupils to enrich visual topic maps with that set the vast amount of single documents or learning objects in context to make them more easily accessible.

6. ACKNOWLEDGMENTS

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7. REFERENCES


