A Generic Framework for Collaborative Multi-perspective Ontology Acquisition

Maayan Zhitomirsky-Geffet, Judit Bar-Ilan, Yitzchak Miller and Snunith Shoham
Department of Information Science, Bar-Ilan University
Ramat-Gan, Israel
972-3-5318351
{zhitomim,barilaj,milleri,shohas}@mail.biu.ac.il

ABSTRACT

The research objective of this work is to develop a general framework that incorporates *collaborative social tagging* with a novel ontology scheme conveying *multiple perspectives*. We propose a framework where multiple users tag the same object (an image in our case), and an ontology is extended based on these tags while being tolerant about different points of view. We are not aware of any other work that attempted to devise such an environment and to study its dynamics. The proposed framework characterizes the underlying processes for controlled collaborative development of a multi-perspective ontology and its application to improve image annotation, searching and browsing. Our case study experiment with a set of selected annotated images indicates the soundness of the proposed ontological model.

Categories and Subject Descriptors

H.3.1 [**Information Storage and Retrieval**]: Content Analysis and Indexing – *thesauruses.*

General Terms

Experimentation, Algorithms

Keywords

Collaborative multi-perspective ontology

1. INTRODUCTION

Tags provide a simple and direct mechanism to create annotations that reflect a variety of facets, and also provide a direct means for embarking upon a search [7]. However, purely tag-based search tends to have low recall performance due to varying vocabulary used by different users. For example, in Flickr some photos of the Western Wall in Jerusalem are annotated as "western wall", others as "wailing wall", or "kotel", or as "westernwall". Tag variability is caused also by tagging that refers to some personal information and associations of the annotators. Thus, the picture of fireworks is tagged by "bride" since they took place during someone's wedding. Obviously, for the searching user such results are irrelevant. Moreover, when an initial search returns a large number of results, tags do not support efficient or intuitive query refinement models.

The alternative approach is to organize information and facilitate search in digital libraries by using concept taxonomies or ontologies. In recent years ontologies have been used to annotate digital content [4], and images in particular [7]. This helps to avoid most of the problems mentioned above and puts some structure and organization on data collections. The main disadvantage of the taxonomy/ontology-based approach is being based on a strict tree of concepts that does not reflect usage and intent [6]. This calls for designing special ontological models that will be suited to reflect multiple perspectives of the described objects expressed by different user tags.

Each of the two above approaches – free tagging based and ontology-based – were explored separately during the last years. We believe that users should not have to choose between pure tag-based models and pure taxonomic models with closed vocabularies. Hence, our approach is to develop a generic framework that incorporates collaborative social tagging by a broad community and a novel ontology type, an efficient *multi-perspective* ontology. Perspectives reflect different users' views and opinions of the image. The main idea is that a perspective is a set or group of several ontological concepts and their relationships and thus it constitutes a new ontological dimension. For example, the perspectives used in our Jewish Cultural Heritage Ontology depicted in Figure 2 are religious, historical, traditional, artistic and geographical perspectives.

2. THE COMBINED APPROACH: MODELING A DYNAMIC MULTI-PERSPECTIVE ONTOLOGY

We construct an ontology solely out of the user tags given for each image which is then further dynamically extended as new images and annotations arrive. The basic set of generic domain-independent relationships in the ontology consists of hyponymy (solid arrows in Figure 2), meronymy (dotted arrows), attribute (dashed arrows), synonymy and instance-of relationships. Synonyms are grouped together into WordNet-style synsets [2]. Each concept is related directly or indirectly to some perspective(s). In addition to the classic inheritance of hypernyms and some cases of meronyms, our framework allows for a new inference rule – inheritance of a perspective through the hyponymy hierarchy relations.

Unlike in [5] and [3], collaborative ontology construction methods and the popular existing systems for image annotation like Flickr, we restrict tags and image indexing through ontology by applying some qualitative and quantitative conditions in our framework, mainly to ensure fine structure, eliminate spam and filter out too personal tags and misspellings. We devised rules for concept and perspective insertion and linking to images:

1. Adding new concepts to the ontology

To ensure consistency and "noise" reduction a tag becomes a concept only if several people used it to describe the same image – i.e. it has a high *tag popularity rank* (TPR) for that image (*TPR(image, tag) > threshold,* where *threshold > 1* and is estimated empirically). Thus, using the same tags again increases

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the popularity rank of these tags which at some point will turn them into concepts in the ontology.

2. Linking concepts to perspectives

The system presents a list of the existing perspectives and each user has to choose her own perspectives for the image being annotated. As a result each concept might be linked to multiple perspectives in the ontology assigned by different users if the *perspective popularity rank* (PPT) exceeds some applied threshold. Thus, associating concepts (coming from tags) to various perspectives is also a collaborative process. Concepts also inherit perspectives from their hypernyms. Users can also add new perspectives to the ontology if they find it necessary.

3. Image indexing via ontology

Images are linked to the perspectives and to particular concepts in the ontology by their annotation tags in order to enable multi-directional retrieval, both through free text search and reaching related images through the tags attached to the image, and through conceptual browsing.

Thus, we observe that user annotation influences the ontological structure which in turn influences the way images are indexed and retrieved in the system.

3. SIMULATION EXPERIMENT: ONTOLOGY ACQUISITION FOR ANNOTATED IMAGES

Here the process is demonstrated for a single image, a ketubah (a Jewish marriage license) that was tagged by twenty users [1]. The tags were associated with perspectives by a different group of fifteen users. The ketubah in Figure 1 is from the eighteenth century from Livorno, Italy – this information was available to the taggers as well. The ketubah is displayed in the Museum of the Italian Jewry in Jerusalem.

Figure 1. Ketubah

The tags assigned by the users that were above the threshold are: ketubah, Italy, Judaism, marriage, ancient ketubah, wedding, Jewish art, Jewish wedding, Livorno, Museum of the Italian Jewry, illustrated ketubah, Judaica, treasures of the Italian Jewry, ancient Hebrew and history.

The second group of users assigned these tags to perspectives (each tag could be assigned to several perspectives). The resulting ontology with the perspectives that passed the threshold for each tag is depicted in Figure 2.

4. CONCLUSIONS AND FUTURE WORK

We have proposed a generic framework where the ontology is developed in parallel and naturally applied from the time the system is launched, rather than being induced artificially on the existing tagging system. Consequently, during the search process,

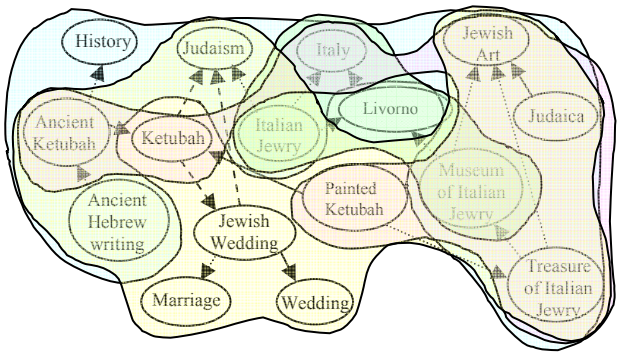

Figure 2. The Ketubah ontology. The religious perspective is light yellow; the historical is light blue; the artistic is light purple and the geographical is light green. The traditional perspective is not marked, since almost all the tags were associated with it.

the user queries are matched against the ontological concepts rather than against raw tags.

Using the induced ontology to control the system vocabulary during image storage and indexing process is expected to increase the precision and reduce "noise" at the retrieval phase. This is achieved by indexing images with corresponding concepts from the ontology, while dropping off too personal and rare user tags. In addition, if a user is only interested in a certain perspective of images our system may easily provide her with this information, and thus save time and browsing effort. After showing the conceptual principles of our framework and its implementation by manual simulation of the processes we will develop ways to turn the proposed rules into algorithms for a semi-automatic approach. We intend to explore the performance of the system where the constructed ontology will be utilized for image retrieval.

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