

Tagging relations to achieve complex search goals

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Abstract—Social search is having a flourishing success for its effectiveness in retrieving high quality information useful to achieve complex search goals. Surprisingly, the potential of the social paradigm at the basis of collaborative tagging in satisfying complex search intents has been unexplored so far. We propose an extended model of folksonomies that allows to compose and tag complex user-defined relations among items, users, and tags. We show that this model offers several means to fulfill complex search tasks that are hard to be achieved by other existing services. Furthermore, we support the validity of our approach through a data-driven analysis on Flickr photosets and we present an online portal that provides this new user experience.

Keywords—Relational folksonomies; social search; collaborative tagging

I. INTRODUCTION

Online search engines are undoubtedly the main fulcrum of Web user activity and they are used to satisfy a great variety of search purposes. Among all the search intents, a considerable portion of traffic on traditional query-based engines is characterized by complex search tasks that can be satisfied only through the aggregation of information from multiple sources [1].

Recently, new Web services designed to meet this demand are successfully emerging under two different paradigms. The first uses automated techniques to assist the user during a complex query session. The latter, so-called *social search*, does not rely on algorithms to retrieve accurate responses to queries, but instead routes queries to other users that can provide their knowledge to answer them. Whether relying on the “*wisdom of the crowds*” —where the best reply is reached by a sort of consensus— or on a “*ask an expert*” principle, social search is expected to be more effective than automatic information retrieval in providing results that well satisfy complex search goals.

In such a scenario, collaborative tagging, one of the first social paradigm for online information retrieval, stopped at an early stage of the Web 2.0 revolution and did not follow the trend outlined by social search. Despite folksonomies produce very high-quality categorization of items [2] and evidence of their effectiveness in improving Web search has been provided in the past [3], up to now tagging is used mainly to accomplish simple search tasks.

We propose a model to realize the unexplored potential of folksonomies in satisfying complex search intents. We present the *relational folksonomy*, an extension of the classical folksonomy that allows to compose complex user-defined *relations* between objects and tag them. While the most known tag-based search engines allow to tag atomic resources like single URLs or multimedia objects, the purpose of our model is to allow users to organize their knowledge or their search experience in meaningful relational structures that represent complex concepts. Resources produced by users or retrieved via classic query-based or tag-based search engines can be connected with relations that express the response to a complex search goal, thus creating a knowledge base that provides solutions to complex search needs of other users.

The advantages of this model over existing systems are manifold. First, arbitrary relations between objects can shape complex knowledge more flexibly than simple set-like collections of items. Second, our model allows to tag not only relations between resources (e.g., URLs) but also between users, tags, and any combination of them. This implies that users can associate other users to items, thus easily triggering the possibility of social search mechanisms, and they can also share their search experience in terms of the relations between the tags used during a search session. Third, the composition of relations can be performed collaboratively by many users; this allows to solve search problems that are too complex or time consuming to be handled by a single user. Last, the relations between objects provide an easy and meaningful way to navigate *inside* the result. In a scenario where the result is a complex object, this kind of navigation could be reasonably more helpful to the user if compared to classic ranked-list visualizations of results.

In the following we provide a deeper insight on the behavior of users tagging complex objects with a data-driven analysis of Flickr (Sec. II), then we present the model together with a case study (Sec. III) and the description of the online service implementing our model (Sec. IV).

II. USER BEHAVIOR IN TAGGING ITEM COLLECTIONS

Tagging complex relations between resources can be useful based on the assumption that a structured cluster

of objects conveys richer semantics than a directory of unrelated resources. This assumption resembles the holistic philosophical current, effectively summarized by the notorious sentence: “*The whole is greater than the sum of its parts*”. We therefore expect that a sort of *Gestalt effect*, i.e. the human capability of understanding a wider, unifying meaning from a system of distinct but related items, can be observed in this context.

As partial evidence that this principle holds in social bookmarking, we perform an analysis on a popular collaborative tagging system to verify what is the relation between the tags assigned to user-generated clusters of resources and the tags assigned to the atomic items that compose the cluster.

We selected the Flickr photo sharing service for our analysis because, to the best of our knowledge, it is one of the few social media websites that allow users to group together tagged resources. In particular, user can compose *photosets* from single photos of their own; furthermore, photosets have a short title that describes the collection. Even if their structure is very simple and not flexible, since it does not allow a real tagging operation on the set, photosets are good candidate to verify the theory.

Using the Flickr API, we collected the information about 230,020 photosets corresponding to 13,317 users and containing an overall amount of 7,188,004 pictures. For every picture, we extracted the tags that its owner has attached to it. We then compared the photoset title —free from stop-words— with the tags inside the photoset.

The first result is that only the 43% of photoset titles overlap with the tags attached to the images inside the set. This means that in more than half of the cases, photo collections have a name that is completely different, from a lexical point of view, from the labels that define the atomic items inside it. Analyzing the overlap between title and tags at a finer grain, we can also observe that, when an overlap occurs, in roughly 50% of the cases the title contains at least one word that does not appear in any of the tags of the photoset resources. This is a hint that very often the title add some semantics to the information specified by the tags of single pictures.

On the other hand, even when an overlap occurs, the tags specify different information than the photoset title. As shown in Fig. 1, the 90% of photosets contains tags that overlap only 20% of the times with the photoset title and, as one can expect, the overlap ratio decreases as the photoset size grows. From the curves in Fig. 1 we also learn that it is quite frequent that a picture in the photoset is labeled with a tag that appears also in the title. This is coherent with the observation that users tend to tag resources with words taken by the title of the resource or of the collection which contains it [4]. Moreover, In Flickr this behavior is somehow broaden by the possibility to tag pictures in batch. Nevertheless, it appears that this phenomenon is limited to a minority of cases.

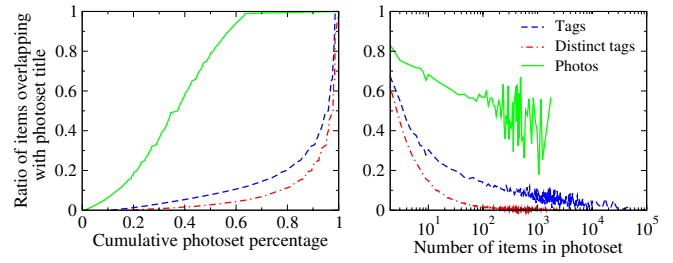


Figure 1. Overlap between photosets title and tags inside the set. The measures are restricted to the 43% of photosets whose title has some overlap with tags. Left plot shows the portion of tags and distinct tags that overlap with their photoset’s title and the portion of photos that are labeled with at least one overlapping tag. Right plot shows the average values of same measures for photosets with the same item size.

This preliminary analysis is not meant to be a formal characterization of the user behavior in classification of aggregated items; however it clearly shows that when resources are aggregated even in a simple set structure, the description that users give at the set level considerably deviates from the labels assigned at atomic level. This observation validates the hypothesis that the meaning of relationship between resources goes beyond the mere aggregation of atoms.

III. MODEL

A common definition of the classic model of a folksonomy is the following [5]:

Definition 1: A **folksonomy** is a tuple $\mathbb{F} := \langle U, T, R, A \rangle$ where U , T , and R are finite sets of *users*, *tags*, and *resources* respectively. The ternary relation $A \subseteq U \times T \times R$ represents the annotation of resources with tags performed by users. Instances $(u, t, r) \in A$ are called **triples**.

We propose an new definition of folksonomy that is a consistent extension of the previous one.

Definition 2: A **relational folksonomy** is a tuple $\mathbb{F}_{\mathfrak{R}} = \langle U, T, R, A, \mathfrak{R} \rangle$ where U , T , R , and \mathfrak{R} are finite sets of users, tags, resources, and relational **bundles** respectively. The ternary relation $A \subseteq U \times T \times \mathfrak{R}$ represents the annotation of bundles with tags performed by users. The set of relational bundles \mathfrak{R} is recursively defined as follows:

$$\left\{ \begin{array}{ll} r \in R & \Rightarrow r \in \mathfrak{R} \\ u \in U & \Rightarrow u \in \mathfrak{R} \\ t \in T & \Rightarrow t \in \mathfrak{R} \\ N \subseteq \mathfrak{R} \wedge \rho \subseteq N \times N & \Rightarrow (N, \rho) \in \mathfrak{R} \end{array} \right. \quad (1)$$

Shortly, in a relational folksonomy users start creating bundles by specifying relations between atomic resources in $R \cup U \cup T$. The relation ρ can be picked among the (extensible) core set of relations specified in Table I. In turn, once a bundle is created, it can be recursively included in a higher order relation together with other bundles or atomic resources, according to Formula 1. This model is very flexible and expressive, since any combination of simple and complex items through any relation can be created by

Relation	Description
Set (\mathcal{S})	$\rho = \emptyset$
List (\mathcal{L})	$\rho = <$, antisymmetric and transitive partial order relation on N
Graph (\mathcal{G})	If items are interpreted like nodes, then $\rho \subseteq N \times N$ determines the set of edges between them. It can be undirected if $(n_1, n_2) \in \rho \rightarrow (n_2, n_1) \in \rho$
Tree (\mathcal{T})	A hierarchical structure obtainable as an acyclic graph \mathcal{G}
Hypergraph	Graph-like relation between elements in the power-set $\wp(\mathcal{R})$, obtainable by the \mathcal{S} relation

Table I
CORE RELATIONS OBTAINABLE IN RELATIONAL FOLKSONOMIES
(FORMULA 1)

the users. Of course, bundles can be tagged for indexing or description purposes.

The main goal of the model is to allow users to link together different resources with a relational structure that conveys complex semantics that would not emerge from a simple collection of the resources. This is particularly useful to organize and share the knowledge on complex topics or to collaboratively build a common relational structure on very articulated matters, in a Wikipedia fashion. Since also users can be inserted into bundles, social information like connections between people can be directly related to resources, for example to identify expertise in some knowledge areas, thus implicitly enabling social search mechanisms. Moreover, the possibility to tag relations between tags allow to index any search process seen as a relation of co-occurring tags in a search session; successful search paths can then be shared to provide other users a guidance to achieve a complex search goal.

Traditional folksonomies are clearly a subset of relational folksonomies that are obtained following the first branch of Formula 1. In this case, \mathcal{R} can contain only elements from R thus the folksonomy reduces to the $\langle U, T, R \equiv \mathcal{R}, A \rangle$ tuple. This means that our model still allows tagging of atomic resources like in classic folksonomies.

The structure of relational folksonomies allows to 1) effectively collect the resources or the knowledge gathered during a complex search activity on a traditional tag-based or query-based engine, 2) add a structured, semantic connection to the accumulated knowledge through *user defined* relations and 3) share the structured knowledge that comes out from this process with other users, using tags.

A. Use case

For illustrative purposes, we present an example of how the relational folksonomies can be used to solve a real-world task.

Suppose that Alice is willing to share her experience about a recent travel through Italy. She went to Venice, then Florence and, at the end, Rome. She visited the main touristic attractions of each city, taking pictures and videos,

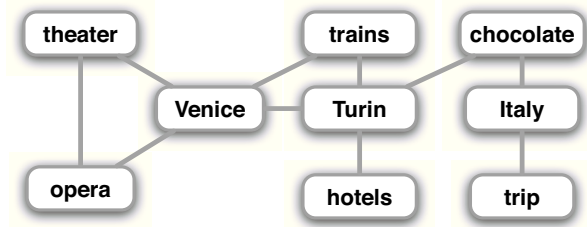


Figure 2. Query graph for a user that wants to visit Italy and enjoy opera and chocolate

writing notes about the hotels she stayed in or the restaurants she went to, collecting online contacts of people she met during the trip.

At the end of her travel, Alice wants to organize and share her experience with friends. Using the proposed approach, she creates a *Set* bundle for each city, containing the media items related to that location; according to Definition 1 and Table I, we refer to these as $(Venice, \mathcal{S})$, $(Florence, \mathcal{S})$, and $(Rome, \mathcal{S})$, respectively (supposing that city names are just macro to identify the collection of resources). To represent the temporal sequence of the trip, she arranges the stages of her journey using a *List* that represents the path covered: $Path = \{(Venice, \mathcal{S}), (Florence, \mathcal{S}), (Rome, \mathcal{S})\}, \mathcal{L}$. Since the model allows to include also people in relations, Alice creates another *Set* bundle $(Participants, \mathcal{S})$ that contains the reference to her fellow travelers. At this point, she shares the bundle $\{(Path, (Participants, \mathcal{S}))\}, \mathcal{S}$ labeled with tags *Italy*, *trip* and *vacation*.

Now assume that Bob is planning a vacation in Italy. He submits a query to the system with the tags *Italy* and *trip*, thus finding the bundle previously posted by Alice. He navigates through the bundle collecting information and possibly tagging or personalizing items. Since Bob has not much time for his vacation, he would like to gather opinions on which of the three cities is most worth seeing, in order to spend more time visiting it. To do so, he sends a request to the users in $(Participants, \mathcal{S})$ to ask for their opinion and suggestions.

Since Bob is keen on opera music, he wants to find an opera house in Venice. So, he submits a query with tags *Venice*, *opera*, and *theater*. At the end of the trip, Bob would also like to visit a place where he can taste good chocolate, so he searches for the tags *Italy* and *chocolate*. He finds that Turin is the Italian capital of chocolate and so he plans to go there by train and lodge in an hotel. Fig. 2 summarizes the *Graph* bundle of tags used by Bob during his search, where tags co-occurring in the same query are linked. This bundle, automatically build by the system during the search session, represents an example of a complex search path performed by a user willing to visit Italy and enjoy opera and chocolate.

Bob, who is interested in continuing its search session later, saves this *Graph* tagging it with *Italy*, *chocolate*, and *opera*. Bob can also choose to share its search experience by publishing the bundle. Doing so, other users can begin their own research starting from the knowledge gathered by Bob, possibly learning relations between concepts which are unknown to them (e.g., Turin and chocolate).

IV. PORTAL

The relational folksonomy model has been implemented in an online Web service available at <http://mumb.di.unito.it>. Although, at this moment, the portal is an early-stage prototype that does not cover the complete set of intended functionalities, it can still provide to the reader a concrete idea of the scenarios that the relational folksonomy model enables. The current portal is structured in three main functional sections: *Search*, *Share*, and *Socialize*.

In the *Search* section (Fig. 3) users can submit queries to the system obtaining a ranked list of atomic results or complex bundles that meet the search criteria. By selecting a bundle the user can navigate its content, tag it or publish a personalized version. On the left side, filters allow to organize the result set by type, source or ownership. On the right side, the upper box contains a weighted list of tags that are related to the words in the current query string. The similarity relation is derived from the semantic concept network built in the Great Minds Think Alike project [6], [7] (<http://greatminds.givealink.org>) that leverages the games with a purpose paradigm to collect high-quality social annotations on Web resources, tags, media content, people, and geographical locations. In the lower box, the current session is represented by the *Graph* bundle that contains the tags used during the search session, where edges between tags indicates their co-occurrence in a query. At this moment, the user is not able to publish the search path, however, this functionality is under development and it will be introduced in the next release since it represents a key functional aspect and a concrete shift from the current approaches.

In the *Share* section users can compose, share and tag bundles. Bundle creation is performed by aggregating content from existing bundles or from social media like Flickr, YouTube, Twitter or any other web services that exports a public API. Since the atomic elements are URIs, the system allows to append anything to a bundle, even users and locations, enabling a geo-social aspect to the engine. Fig. 4 shows the process of adding a YouTube video to a bundle set. The current prototype provides the ability to create only bundle sets containing photos, videos or tweets. However, it is worth noting that the prototype architecture has been carefully designed to easily support new relations or media channels in future releases.

The *Socialize* section (not implemented yet) is intended to foster the creation of social links between users building a community around them. The system will suggest people

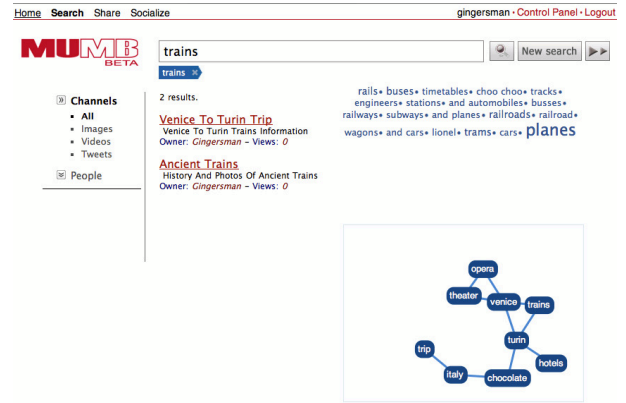


Figure 3. Search section

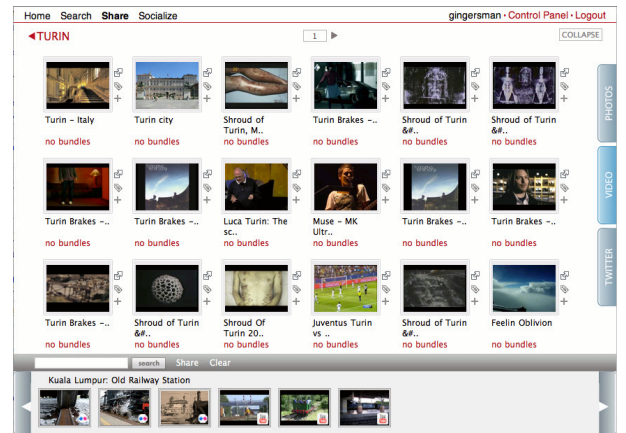


Figure 4. Adding a YouTube video to a bundle set

interested in similar topics and will enable discussion panels to share the knowledge of experts.

The portal allows anonymous users to search, navigate and create a bundle; instead, sharing, tagging and connecting to people requires a login procedure. Users may login using an account from some of the most popular social media sites like Facebook, Yahoo!, Google and many others. Any service that implements the OpenID protocol is accepted. In the *Control Panel* the user can manage her multiple digital identities and connect them to the local id, enabling services like discovery, personalized recommendation, social networking, and so on.

V. RELATED WORK

In the following we discuss previous work in extending classic collaborative tagging services with new features and in improving search with social tools.

A. Improving and extending folksonomies

Since the scientific community has turned his attention on folksonomies, many aspects of collaborative tagging systems

have been studied and developed. Recent research on social bookmarking includes the analysis of behavioral patterns, topical trend detection in tagging [8], [9], and studies about the relationship between folksonomies and taxonomical categorization of items [10]. Several efforts have also been spent in improving the tagging systems quality of service by structuring and properly ranking search results in tag-based search [5] or proposing services based on the information extracted from folksonomies, like personalized recommendation services [11], [12] or social link suggestion [13].

Some work has been done in extending tag-based search from a navigational point of view. Services like Yahoo! TagExplorer allow to specify narrower tags at each search step with the aim of quickly converging to a small set of resources, and other work has been done in realizing platforms for tag navigation [14], automatic tag clustering [15], and in improving the user experience in navigational search [16].

Currently, some of the major social bookmarking services support some sort of grouping functions. Del.icio.us allows to create *tag bundles*, which are tagged sets of tags, Bibsonomy support *relations* between tags in a hierarchical fashion, and, as seen above, Flickr allows the construction and tagging of *photosets*. Nevertheless, these solutions lack of generality since they are designed to fit their own single domain and hardly adaptable to more complex relations than the simple set. For instance, more general features like nesting of relational structures or composition of different types of relation are not explicitly supported by these models.

Perhaps, the only relevant attempt in changing the paradigm at the basis of folksonomies has been proposed in the GroupMe! project [17]. Similarly to our work, GroupMe! is based to an extension of the classic Folksonomy formulation that allows the creation of groups of multimedia resources. GroupMe! is able to capture just one of the many relations we introduce in our model and, even more important, it deals only with the resource dimension of the folksonomy, thus not being able to embed social search features like tagging and sharing of successful search paths or indexing users and associate them to particular resources.

Finally, note that the problem of improving the quality of the relations between concepts has been somehow addressed also in context different from collaborative tagging systems. The work by Völkel et al. [18], for instance, is aimed to extend the links between Wikipedia pages with semantic modifiers that could be used by editors to specify the nature of connections between Wikis.

B. Social search

On the other hand, social search is having a great success so that also traditional query-based search engines are turning to a more social perspective to follow this trend.

Originally, the idea of “social search” was referred to the task of searching a particular person through a path between users in a social network [19], but soon its meaning evolved

to denote a process of search for knowledge *through* a social platform. In fact, complex queries that cannot be easily satisfied by conventional search engines can be efficiently answered if they are submitted to a social substrate of human computers, especially if they are experts in the query subject. It has been shown that users perceive many advantages in social search like getting personalized answers by trustworthy experts or the possibility of getting satisfactory responses to subjective questions [20]. Q&A bulletin boards like Yahoo! Answers have been the earliest examples of social search, but recently this paradigm evolved in services like Aardvark [21], where queries are automatically routed to users that declared their expertise in the subject of the submitted question.

The power of social search facilities is complementary with the services offered by traditional search engines. The synergy between the two paradigms have been already exploited by services like Google Confucius [22], where users are redirected to a social search platform for some query categories. Another social approach to deal with complex query activity has been adopted by Yahoo! SearchPad [1], a service that automatically recognizes the boundaries of a complex search mission in a query stream, allowing the user to save the session history and, subsequently, to share the steps of a successful search with other users.

The extension of the folksonomy paradigm that we propose in this paper is aimed to fill the gap between the features offered by traditional collaborative tagging systems and the emerging trend of social search to satisfy complex searches.

VI. CONCLUSIONS

We propose an extension to the folksonomy model that enables to tag complex user-defined relations between users, tags, and items. As a premise, we analyze the connection between tags associated to Flickr photosets and tags related to the single pictures composing the photoset. We observe that even this simple form of aggregation conveys richer semantic than a directory of unrelated objects. Accordingly, we define the concept of *relational folksonomy* presenting a concrete example of how they can be used to solve real-word tasks. To the best of our knowledge, this is the first attempt to leverage the power of folksonomies to enable social search and the achievement of complex search missions in a collaborative way. An online Web portal is presented as a reference implementation of the model.

As a future work, we plan to collect usage data from the portal and analyze it to corroborate the validity of our model. Moreover, we are exploring the possibility to use the user-generated relations to implement a class of recommender systems that do not use automatic similarity metrics between objects/users, but leverages social mechanisms to create subjective serendipitous suggestions that reduce the overspecialization problem that affects many recommenders.

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