

Collective Search and Recommendation in Social Media

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ABSTRACT

This PhD thesis proposal is focused on proposing solutions to the problem of collective search and recommendation in social media. User and data are two fundamental elements under social media environment. To cope with the semantic gap between social media data and semantic meaning, and the complexity of user intent and requirements, we propose to conduct research on three stages: (1) multimedia content analysis; (2) user understanding and (3) collective search and recommendation. We address the large-scale, multi-modal and heterogeneous characteristics of social media analysis by developing methodology from factor analysis, generative topic model and collaborative filtering. Progresses and advances along the three research lines have been presented, with future directions and open discussions concluded in the end.

Categories and Subject Descriptors

H.4 [Information Systems Applications]: Miscellaneous

General Terms

Algorithms, Theory

Keywords

Social Media, Collective Search, Collective Recommendation

1. INTRODUCTION

Generated in the context of Web2.0, social media is a new way for multimedia information exchange and sharing. Its rapid development has attracted attentions from more users than ever before all over the world. With the extensive infiltration of various social medias, massive rich media information has been generated. How to effectively and efficiently conduct data mining for accurate search and recommendation services, becomes the key problem to the development of modern Internet.

Social media has offered a real-world platform for conducting researches (e.g., as data pooling or evaluation avenue [1]) and im-

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MM'12, October 29–November 2, 2012, Nara, Japan.

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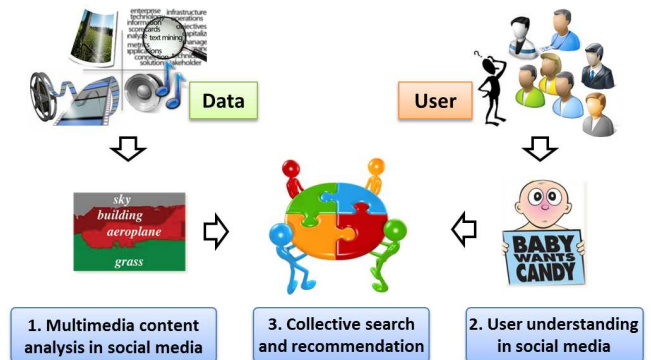


Figure 1: The general framework for collective search and recommendation in social media.

plementing novel applications (e.g., photo sharing¹, social game²), while at the same time brought challenges due to its characteristics like large-scale, multi-modality and heterogeneity. Collective search and recommendation, which exploits the various media collaborations and user interactions to improve user intent understanding as well as social media analysis, well fits into the local symbiotic and collective natures and serves as one practical solution to push desired information to target users [2].

Collective search and recommendation in social media features in: (1) social media as platform; (2) collective analysis as methodology and (3) search and recommendation as applications. **Data** and **user** run through the three-folds, which are the basic elements of social media and the fundamental research objects of collective analysis. The goal of search and recommendation is exactly to correlate the most relevant data to the most desired users. Regarding the semantic gap between social media data and high-level semantics, and the complicate user intent and needs, we propose a general framework for collective search and recommendation in social media, which includes three main stages: (1) Multimedia content analysis in social media; (2) User understanding in social media and (3) Collective search and recommendation based on multimedia content analysis and user understanding. The diagram is illustrated in Fig. 1.

To cope with the above issues, we will resort methods from multimedia content analysis, social network analysis, pattern recognition and machine learning. Development of methods tailored to collective search and recommendation will contribute to a wide range of problems, which, we believe, is fundamental to the advancement of social media analysis and will raise many exciting

¹ Pinterest. <http://pinterest.com/>

² Draw Something. <http://itunes.apple.com/app/draw-something/>

research challenges. The pursuit of the thesis is expected to make the following main contributions:

- Alleviate the semantic gap problem in multimedia content analysis. Integration of user interaction in social media will help discover latent semantic correlation between various media data and reduce the notorious semantic gap;
- Enhance user modeling in user intent understanding. Under social media circumstances, there exist rich user activity data derived from interactions between users and media documents, which remain potential to be exploited for complete user modeling and accurate intent understanding;
- Enrich researches in related information science fields. Traditional methods of multimedia analysis can not be directly applied to social media analysis due to the significant social attributes. Investigation on related research theories, such as social network analysis and organizational behavior study, will advance breakthroughs of key technologies in interdisciplinary fields.

The rest of this paper is organized as follows. Section 2 presents some previous work about social media analysis and collective search and recommendation. Section 3 summarizes our approach to tackle with the problem of collective search and recommendation. In section 4, we introduce the progress and ongoing work. Finally, section 5 concludes this thesis and some open issues are provided.

2. RELATED WORK

Extensive efforts have been focused on the topics of (1) social media-oriented multimedia content analysis, (2) user understanding in social media and (3) collective search and recommendation. We just list a few of them in this section.

Semantic labeling is the fundamental problem in multimedia content analysis, whose task is to conduct joint modeling between visual and textual information from a set of training samples. Under social media environment, large-scale user generated metadata (e.g., tag) provides valuable resources as training samples. However, the noisy or incomplete correspondence between the multimedia documents and tags prohibits them from being leveraged for precise multimedia retrieval and effective management [3]. Social tag analysis, which targets at annotating, denoising and enriching tags, is widely utilized to tackle this issue. Existing social tag analysis methods [4, 5, 6, 7, 8] exploited the semantic correlation between tags and visual similarity of multimedia documents to improve the bilateral correlation, while the user interaction as one of the most intrinsic entities in social media communities has been largely ignored. In this thesis, we propose to explicitly introduce user factor into the problem of social tag analysis, by which we can gain more insight to user-generated metadata understanding and thus assist multimedia content analysis.

User understanding consists of two primary topics as user profile construction and social relation modeling. Users conduct various activities in social media websites, which naturally indicate their preferences and can be used for user profile construction. Search history is utilized as the resource for user profile construction in [9, 10]. In [11, 12], the authors proposed to construct user profile for personalized search with their collaborative annotation activities. Other research works attempt to construct user profiles based on their browsing history or the document they collected [13]. [14] provides a good overview of earlier work representing users from various online activities. The basic premise behind exploiting social relations is that the preferences of other users, who are socially

close to the target user, provide a good indication of his/her preference. Several approaches have directly employed users' social relations to assist collective search and recommendation. Bender et al. [15] assumed that a document receives extra "friendship" score if it is tagged by the searcher's friend. Carmel et al. [16] explicitly defined familiar and similar scores to model relations between users, with familiar score calculated from social link and similar score estimated from collaborative activities. Social network analysis method is relatively new to user modeling in multimedia fields. Zhuang et al. [17] has introduced the problem of continuous social link modeling in photo sharing websites. In this thesis, we propose to seamlessly integrate various user activities for user modeling by addressing the issues of noise and sparsity. Moreover, we will develop social network analysis methods to analyze more complicated social relations.

Gou et al. [18] proposed a Multi-level Actor Similarity method to estimate the social similarity between users for collective video search. Lin et al. [19] leveraged the discovered community and introduced a community-oriented re-ranking scheme for collective search. In [20], the co-visitation statistics among videos are exploited and a random-walk alike method is proposed for collective video recommendation. Yang et al. [21] proposed to simultaneously consider user relevance feedback and video collaboration for video recommendation. In this thesis, we propose to develop a theoretical framework for collective search and recommendation, which is capable of jointly modeling the output of multimedia content analysis and user modeling. Moreover, we will design more complicated applications to exert the characteristics of social media data.

3. THE PROPOSAL

We have shown above that although the related topics have attracted considerable research interests, these work either fail to thoroughly exploit the social attributes when analyzing multimedia content, or do not fully utilize various user activities when conducting user modeling. Moreover, a theoretical framework of collective search and recommendation to combine the output of multimedia content analysis and user understanding is urgently needed. To address the problem of collective search and recommendation in social media, we plan to proceed in three stages which we describe as follows.

- **Social media-oriented multimedia content analysis:** Multimedia document is the core component of social media. Multimedia content analysis serves as the basis of collective search and recommendation. Traditional image and video analysis methods rely on low-level feature descriptors like color, edge and texture, which have inevitable "semantic gap" with the high-level semantics of human understanding. In the context of social media, interactions and interrelations between users and multimedia content provide a feasible solution to this problem. It is of great significance to leverage the context, annotation, review metadata and cross-media associations for better multimedia content analysis.
- **User understanding in social media:** To truly bridge the gap between data and user requirements in collective search and recommendation services, another key issue is user intent understanding. Learning user interests and preferences by analyzing the user-user, user-content interactions and mining various social activities is an important step for user intent understanding. Moreover, with social and clustering attributes, social media can be seen as the projection of real

world community on the web, which makes social network analysis essential to under modeling in social media.

- **Collective search and recommendation:** Given results from multimedia content analysis and user modeling, the most challenges in collective search and recommendation include utilization of local symbiotic and collective characteristics, leveraging the integration and propagation of various relationships and integrating the results from multimedia content analysis and user understanding in a theoretical framework.

3.1 Methodology

3.1.1 Multimedia Content Analysis

Social media websites allow users as owners, taggers, or commenters for their contributed documents to interact and collaborate in a social media dialog. The typical structure of a social media ecosystem includes entities of user, multimedia document and tag, which interrelate with each other. We propose to employ the concept of factor to represent each entity. The observed entity correlation³ is captured in an original tensor, with each mode corresponding to one entity and each non-zero tuple corresponding to one observed correlation. Multimedia content analysis can thus be conducted through factor analysis methods, e.g., tensor decomposition to enhance and reconstruct the ternary correlations between entities.

Two major challenges lie on how to deal with the sparsity and noise issues. Other than the observed inter-entity correlation, rich interactions in social media also provides various intra-entity information⁴, which can be utilized as regularization terms when performing tensor decomposition from sparse original tensors. Moreover, by addressing the characteristics of user social activities, such as the incomplete and ambiguous user-generated tagging data, we are capable of filtering noises and making full use of the observed data.

3.1.2 User Understanding

User necessarily interact with multimedia documents and communicate with other users to generate rich social activity data. The goal of user understanding is to estimate user interest and preference by exploiting the user history activity data. Topic model, which flourishes after Blei's LDA [22], has been applied to many fields such as text mining, computer vision and information system thanks to its solid theoretical foundation and good flexibility. The concept of topic well fits into the task of extracting underlying semantics from unsupervised user activity data. We propose adapted topic models to perform user intent understanding.

Moreover, generative models will be employed to infer the latent social relations between users. The basic premise behind this is to simulate the generation process of the observed user activity data, which is assumed as the derivation of interaction between user's own preference and social influence. Generative topic model distinguish itself in that we can incorporate suitable prior knowledge into the modeling process, which enables formulation of complicated correlation inference into semi-structure problem.

3.1.3 Collective Search and Recommendation

The theoretical framework of collective search and recommendation has two goals. On one hand, the output of multimedia content

³ E.g., The user contributed tagging data indicates the observed user-image-tag ternary correlation.

⁴ E.g., The user-user relation can be calculated from user's explicit social network or collaborative neighborhoods.

analysis and user understanding need to be unified in one framework. On the other hand, different from traditional methods that treat search and recommendation as two separate problems, we propose to unify collective search and recommendation in the same framework by formulating user explicit or implicit preference as time-evolving queries, which are then sent to the matching and ranking search modules.

Risk minimization is a popular information retrieval framework with solid theoretical foundation [23]. It formulates query and document by language models, where queries and documents are modeled respectively from different generative processes. Since we formulate recommendation as a generalized search problem, we will develop a unified theoretical collective search framework under risk minimization theory. In particular, the derivations from factor analysis-based multimedia content analysis and topic model-based user understanding are employed to construct the generative processes for multimedia documents and user queries, and the retrieval of relevant documents is solved from the perspective of Bayesian decision theory, whose goal is equivalent to minimize an expected loss.

4. PROGRESS

To date, we have presented advances in the three stages. A list of contributions includes:

- A method of image tag refinement based on user-image-tag ternary analysis has been presented in *TMM* [24]. We have introduced user information into social tag analysis and proposed a regularized tensor decomposition method to solve the problem of image tag refinement.
- A method of video organization based on semantic hierarchy mining on user-generated tags has been presented in *JM-M* [25]. A relational version of hierarchical topic model has been proposed to construct a novel multi-modal video analysis framework.
- A method of user modeling based on annotation enrichment and user-specific topic modeling has been presented in *TM-M* [26]. The variations in user's vocabulary and background are considered and applied in the task of personalized image search.
- A method of topic-sensitive social relation mining has been accepted as long paper by *MM* 2012 [27]. In this work, we present a theoretical framework for collective search jointly modeling the user preferences and social influences.
- Application of mobile activity recommendation based on probabilistic Markov ranking is submitted as long paper to *Ubi-comp* 2012. We introduce a novel problem of activity planning by simultaneously recommending series of local entities.
- A novel clustering-based video search result display interface has been presented in *TOMCCAP* [28]. The intrinsic hierarchical structure in the retrieved video collection is exploited for video semantic clustering.

Currently, we are working on developing a unified framework for collective search and recommendation. In addition, we are investigating the correlation between the proposed theoretical collective search framework with other collective search methods.

5. CONCLUSION

In this thesis, we have proposed to deal with the challenging problem of collective search and recommendation in social media. Although we have achieved advances on the proposed three research stages, there exist a lot of issues open for investigation before complete social media analysis, total user understanding and perfect correlation user and information in social media: (1) Constructing a indexing knowledge database for social media information. (2) Unifying user behavior analysis from various online activity data. (3) Investigating on the general theoretical framework for collective search and recommendation in social media.

6. ACKNOWLEDGEMENT

This work was supported in part by National Program on Key Basic Research Project (973 Program, Project No. 2012CB316304) and the National Natural Science Foundation of China (Grant No. 90920303, 61003161).

7. REFERENCES

- [1] Mor Naaman. Social multimedia: highlighting opportunities for search and mining of multimedia data in social media applications. *Multimedia Tools Appl.*, 56(1):9–34, 2012.
- [2] Jiang Yang, Meredith Ringel Morris, Jaime Teevan, Lada A. Adamic, and Mark S. Ackerman. Culture matters: A survey study of social q&a behavior. In *ICWSM*, 2011.
- [3] Dong Liu, Xian-Sheng Hua, and Hong-Jiang Zhang. Content-based tag processing for internet social images. *Multimedia Tools Appl.*, 51(2):723–738, 2011.
- [4] Yohan Jin, Latifur Khan, Lei Wang, and Mamoun Awad. Image annotations by combining multiple evidence & wordnet. In *ACM Multimedia*, pages 706–715, 2005.
- [5] Changhu Wang, Feng Jing, Lei Zhang, and Hong-Jiang Zhang. Content-based image annotation refinement. In *CVPR*, 2007.
- [6] Dong Liu, Xian-Sheng Hua, Linjun Yang, Meng Wang, and Hong-Jiang Zhang. Tag ranking. In *WWW*, pages 351–360, 2009.
- [7] Lin Chen, Dong Xu, Ivor Wai-Hung Tsang, and Jiebo Luo. Tag-based web photo retrieval improved by batch mode re-tagging. In *CVPR*, pages 3440–3446, 2010.
- [8] Guangyu Zhu, Shuicheng Yan, and Yi Ma. Image tag refinement towards low-rank, content-tag prior and error sparsity. In *ACM Multimedia*, pages 461–470, 2010.
- [9] Lynda Tamine-Lechani, Mohand Boughanem, and Nesrine Zemirli. Personalized document ranking: Exploiting evidence from multiple user interests for profiling and retrieval. *JDIM*, 6(5):354–365, 2008.
- [10] Mariam Daoud, Lynda Tamine-Lechani, Mohand Boughanem, and Bilal Chebaro. A session based personalized search using an ontological user profile. In *SAC*, pages 1732–1736, 2009.
- [11] Yi Cai and Qing Li. Personalized search by tag-based user profile and resource profile in collaborative tagging systems. In *CIKM*, pages 969–978, 2010.
- [12] Manel Mezghani, Corinne Amel Zayani, Ikram Amous, and Faïez Gargouri. A user profile modelling using social annotations: a survey. In *WWW (Companion Volume)*, pages 969–976, 2012.
- [13] Kazunari Sugiyama, Kenji Hatano, and Masatoshi Yoshikawa. Adaptive web search based on user profile constructed without any effort from users. In *WWW*, pages 675–684, 2004.
- [14] Ching man Au Yeung, Nicholas Gibbins, and Nigel Shadbolt. A study of user profile generation from folksonomies. In *SWKM*, 2008.
- [15] Matthias Bender, Tom Crecelius, Mouna Kacimi, Sebastian Michel, Thomas Neumann, Josiane Xavier Parreira, Ralf Schenkel, and Gerhard Weikum. Exploiting social relations for query expansion and result ranking. In *ICDE Workshops*, pages 501–506, 2008.
- [16] David Carmel, Naama Zwerdling, Ido Guy, Shila Ofek-Koifman, Nadav Har’El, Inbal Ronen, Erel Uziel, Sivan Yogev, and Sergey Chernov. Personalized social search based on the user’s social network. In *CIKM*, pages 1227–1236, 2009.
- [17] Jinfeng Zhuang, Tao Mei, Steven C. H. Hoi, Xian-Sheng Hua, and Shipeng Li. Modeling social strength in social media community via kernel-based learning. In *ACM Multimedia*, pages 113–122, 2011.
- [18] Liang Gou, Hung-Hsuan Chen, Jung-Hyun Kim, Xiaolong Zhang, and C. Lee Giles. Sndocrank: a social network-based video search ranking framework. In *Multimedia Information Retrieval*, pages 367–376, 2010.
- [19] Lin Pang, Juan Cao, Yongdong Zhang, and Shouxun Lin. Leveraging collective wisdom for web video retrieval through heterogeneous community discovery. In *ACM Multimedia*, pages 1485–1488, 2011.
- [20] Shumeet Baluja, Rohan Seth, D. Sivakumar, Yushi Jing, Jay Yagnik, Shankar Kumar, Deepak Ravichandran, and Mohamed Aly. Video suggestion and discovery for youtube: taking random walks through the view graph. In *WWW*, pages 895–904, 2008.
- [21] Bo Yang, Tao Mei, Xian-Sheng Hua, Linjun Yang, Shi-Qiang Yang, and Mingjing Li. Online video recommendation based on multimodal fusion and relevance feedback. In *CIVR*, pages 73–80, 2007.
- [22] D. Blei, A. Ng, and M. Jordan. Latent dirichlet allocation. *Journal of Machine Learning Research*, 7:993–1022, 2003.
- [23] John D. Lafferty and ChengXiang Zhai. Document language models, query models, and risk minimization for information retrieval. In *SIGIR*, pages 111–119, 2001.
- [24] Jitao Sang, Changsheng Xu, and Jing Liu. User-aware image tag refinement via ternary semantic analysis. *IEEE Transactions on Multimedia*, 14(3):883–895, 2012.
- [25] Jitao Sang and Changsheng Xu. Facet subtopic retrieval: Exploiting the topic hierarchy via a multi-modal framework. *Journal of Multimedia*, 7(1):9–20, 2012.
- [26] Jitao Sang, Changsheng Xu, and Dongyuan Lu. Learn to personalized image search from the photo sharing websites. *IEEE Transactions on Multimedia*, 14(4), 2012.
- [27] Jitao Sang and Changsheng Xu. Right buddy makes the difference: An early exploration of social relation analysis in multimedia applications. In *ACM MM*, 2012.
- [28] Jitao Sang and Changsheng Xu. Browse by chunks: Topic mining and organizing on web-scale social media. *TOMCCAP*, 7(1):1–18, 2011.