



Geo-temporal distribution of tag terms for event-related image retrieval



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ABSTRACT

Media sharing applications, such as Flickr and Panoramio, contain a large amount of pictures related to real life events. For this reason, the development of effective methods to retrieve these pictures is important, but still a challenging task. Recognizing this importance, and to improve the retrieval effectiveness of tag-based event retrieval systems, we propose a new method to extract a set of geographical tag features from raw geo-spatial profiles of user tags. The main idea is to use these features to select the best expansion terms in a machine learning-based query expansion approach. Specifically, we apply rigorous statistical exploratory analysis of spatial point patterns to extract the geo-spatial features. We use the features both to summarize the spatial characteristics of the spatial distribution of a single term, and to determine the similarity between the spatial profiles of two terms – i.e., term-to-term spatial similarity. To further improve our approach, we investigate the effect of combining our geo-spatial features with temporal features on choosing the expansion terms. To evaluate our method, we perform several experiments, including well-known feature analyzes. Such analyzes show how much our proposed geo-spatial features contribute to improve the overall retrieval performance. The results from our experiments demonstrate the effectiveness and viability of our method.

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1. Introduction

The proliferation of web and social media-based photo sharing has not only opened many possibilities but also resulted in new needs and new challenges. Despite recent developments and technological advances within – e.g., web-based media sharing applications, the continuously increasing amount of available information has made the access to these photos still a demanding task. In general, we can address this challenge by allowing the photo collections to be organized and browsed through the concept of event (Papadopoulos, Troncy, Mezaris, Huet, & Kompatsiaris, 2011; Ruocco & Ramampiaro, 2012). Also, most users are generally familiar with searching photo collections using events as starting points. Thus, aiming at supporting the detection and search of event-related photos, we propose an event retrieval framework to improve the state-of-the-art in real-life event retrieval systems in term of retrieval effectiveness.

Focusing on media sharing applications, an *event* refers to “something happening in a *specific* place at a *specific* time, and tagged with a *specific* term” (Ruocco & Ramampiaro, 2012). With an event-retrieval system, we can assume two types of scenarios: (1) A user directly retrieves media resources related to a particular event; and (2) a user uses a given tagged photo representing an event to retrieve other photos related to any similar events from a large image collection. In this work, we

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mainly focus on scenario (2). Due to their characteristics, pictures in photo sharing applications such as *Flickr*¹ and *Panoramio*² are particularly interesting. For example, most of such pictures are accompanied with contextual metadata and other related information added by users, such as *Title*, *Tags*, *Description*, temporal information represented by the picture capture and upload times, and geolocation. Hence, with photo sharing applications in mind, we study how we can exploit contextual metadata to retrieve event-related pictures.

The main goals of this work are (1) to build a framework to extract a set of geographical features from geographical raw data of documents or pictures, and (2) to develop an approach to allow effective retrieval of event-based images. Specifically, we develop a set of geographical features that can capture the characteristics of the geographical distributions of social (or user) tags. Further, we investigate how we can combine these features with the state-of-the-art temporal features to improve the retrieval performance of an event-based image retrieval system. Finally, we explore integrating a machine-learning-based approach with our retrieval system. We study how these features can be used in a query expansion framework. Here, we are especially interested in the contributions of the features on the selection of expansion terms from feedback documents.

To this end, we propose a novel framework that improves the retrieval effectiveness of tag-based image search by including the geographical profile of terms. We have developed a new method for extracting spatial features using information about the geographical distribution of tags. Our main idea is to use such features to characterize the clustering tendency of tag terms and the geographical correlation between two geographical distributions of two tags. Spatio-temporal information retrieval is an established field already. However, existing approaches have mainly been concerned with point-of-interests (POI) extraction (Rae, Murdock, Popescu, & Bouchard, 2012) and trajectory mining (Yin, Cao, Han, Luo, & Huang, 2011). With the constantly increasing number of geotagged pictures – e.g., in Flickr,³ exploring the raw geographical metadata has become increasingly important.

In summary, the main contributions of this paper are as follows. First, we propose a new robust set of geographical features that can be used (1) to determine the clustering tendency of tags by analyzing the geographical structure of their geographical distribution, and (2) to analyze the tag-relatedness between two tags by exploring the correlation between the geographical distributions. To do this, we have developed new measures derived from a well-founded Exploratory Analysis theory from Statistics. More specifically, we adapt the *Ripley's K-function* and *Ripley Cross-K function* (*K-function* and *cross-K function* for short) (Ripley, 1976) as part of our approach to extract the geographical features. Second, we show how our features can be incorporated in a machine learning-based query expansion model to improve the ability to select good expansion terms. In addition, we demonstrate how these features can be combined with existing document-based approaches and temporal features to achieve improved retrieval performance. Third, through our experimental evaluation we show the effectiveness and practical feasibility of our approach. This includes comparing with both baseline retrieval models and baseline approaches for geo-temporal tag-relatedness. Fourth, we perform a thorough analysis to show the effectiveness of our proposed geographical features – in the afore-mentioned machine learning-based query expansion process.

The rest of this paper is organized as follows. To put our research in a perspective Section 2 provides an overview of approaches related to our work. Section 3 gives an overview of the preliminary theory underlying our approach and defines the problems addressed in this paper. Section 4 presents our proposed geographical features and explains how we extract them. Section 5 describes our framework applying these features in a learning-based re-weighting process for a query expansion model. Section 6 explains our experimental setup. Section 7 presents the results from our experiments. Finally, in Section 8 we conclude the paper and outline our future work.

2. Related work

In the past decades, detection of events from textual document streams and databases has been treated extensively in the literature (Allan, Papka, & Lavrenko, 1998; Brants, Chen, & Farahat, 2003). However, although mining and retrieving pictures related to real-life events is an active field, it is still not a fully mature research domain (Ruocco & Ramampiaro, 2012; Gkalelis, Mezaris, & Kompatsiaris, 2010; Trad, Joly, & Boujemaa, 2011). Most related approaches have been aimed at *extracting* events from different types of datasets. To the best of our knowledge, only few works have addressed the problems of *retrieval* of events in connection to media sharing, and many of these approaches were presented in the Social Event Detection (SED) task at MediaEval⁴ (Papadopoulos et al., 2011), where the main objective was to propose event retrieval systems for Flickr pictures.

A research area closely related to ours is pseudo-relevance feedback. Generally speaking, pseudo-relevance feedback refers to techniques to average top-retrieved documents to automatically expand an initial query. It has been studied widely in information retrieval both to extend existing retrieval models (Cao, Nie, Gao, & Robertson, 2008; Lavrenko & Croft, 2001; Tao & Zhai, 2006; Zhai & Lafferty, 2001), and as part of query expansion frameworks (Carpineto, de Mori, Romano, & Bigi, 2001; Rocchio, 1971). Specifically, (Lavrenko & Croft, 2001; Zhai & Lafferty, 2001) propose two methods – the *Relevance Model* and the *Mixture Model*, respectively – to include feedback information in the Kullback–Leibler (KL) divergence retrieval

¹ See <http://www.flickr.com/>.

² See <http://www.panoramio.com/>.

³ Around 220 M of Flickr pictures are geotagged. See also <http://www.flickr.com/map/>.

⁴ <http://www.multimediaeval.org/mediaeval2011/>.

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