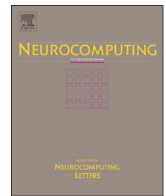




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Neurocomputing

journal homepage: www.elsevier.com/locate/neucom

Analyzing Flickr metadata to extract location-based information and semantically organize its photo content



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ARTICLE INFO

Article history:

Received 2 November 2013

Received in revised form

1 December 2014

Accepted 26 December 2014

Available online 29 May 2015

Keywords:

Social media content analysis

Geo-tagging

Tags

Content clustering

Information processing

ABSTRACT

The first step towards efficient social media content analysis is to understand it and identify means of user interaction. Trying to study the problem from the user perspective, we analyze user-generated photos uploaded to famous Flickr social network, in order to extract meaningful semantic trends covering specific research aspects, like content popularity, spatial areas of interest and popular events. Initially, we select a geographical area of social interest, like a city center, defined by a strict bounding box. We then cluster photos taken within the box based on their geo-tagging metadata information (i.e., their latitude and longitude information) and divide large areas into smaller groups of fixed size, which we will refer to as “geo-clusters”. Within these geo-clusters, we further identify semantically meaningful “places” of user interest, by analyzing any additional textual metadata available, i.e., user selected tags that characterize each place's photos. By post-processing the latter, we are then able to rank them and thus select the most appropriate tags that describe landmarks and other places of interest, as well as events occurring within these places of interest. As a next step, we place these tags on a map and help users to intuitively visualize places of interest and the actual photo content at a glance. Finally, we examine the temporal dynamics of analyzed photos over a long period of time, so as to obtain the underlying trends to be identified within this kind of social media generated content.

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1. Introduction

The recent growth of social networks coupled together with an extreme amount of multimedia content data, mostly in the form of digital still images, deriving from both personal and social media, gave rise to interesting applications and technologies that support them. In this work we initiate our research by first trying to understand the mechanisms that allow users to interact and exchange photo content on social media platforms such as Flickr¹ and by analyzing the underlying trends that accompany mass online multimedia content sharing. Being the center of attention, online user-generated multimedia content met an unprecedented interest increase in terms of its organization and manipulation. Consequently, there is an urgent and growing need to facilitate effortless user access and manipulation to these rather unorganized and unsorted media archives, in order for typical users (a) to take advantage of the inherent additional meta-information that is present within them (e.g., geo-tags) and (b) to exploit it. Typical approaches for assisting such information access, like browsing,

searching, filtering, or recommendation techniques, although quite advanced in the textual domain, are still in their early steps with respect to the mass online multimedia content domain.

The latter observation may be attributed in the most part to the lack of sufficient – additional to the actual content itself – textual annotations, tags or geo-tags associated with multimedia content, which firstly hinders the application of text-based retrieval techniques and secondly, obstructs efficient organization of such enriched multimedia content. In addition, the art of analyzing and identifying patterns of temporal variation with respect to online content in general, forms another difficult task, mainly due to the fact that human behavior – that is inherent behind the temporal variation – is considered to be highly unpredictable and outside of any known model; the latter ranging typically between “random” [40] and “highly correlated” [10] states.

In this paper we shall focus on a subset of the above described information handling problems, which, however, lies within current top research trends and applied services: we aim to analyze large user-generated digital photos collections (such as the ones derived from Flickr), in order to select the most appropriate meta-tags to describe a geographical area of interest and thus characterize the content itself in terms of its semantics, spatial and chronological context. In the following we present a holistic attempt of our work methodology, starting from its very first steps on photo clustering

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¹ <http://www.flickr.com>

based on their respective geo-information, up to: (a) each geo-cluster's textual metadata analysis, (b) the extraction of meaningful semantic trends covering the specific geographical areas of interest and (c) the final computation of their temporal dynamics over a long period of time. In the evolution of our work description we shall also illustrate some additional intermediate steps, such as placing clusters and tags on a map to help readers intuitively understand both the reasoning in the points of interest selection and the actual visual content associated. As a result, the *main contributions* of this work may be summarized as follows:

- (i) we propose a two-level, semantically meaningful clustering scheme on geo-tags, based on KVQ [55]. We utilize this scheme in order to create fixed-size clusters that would semantically correspond to “places”; we define the latter to be a rather compact and meaningful geographic area. We only select “places” that involve the collective intelligence of Flickr users, or in other words “places” that show at least some user interest,
- (ii) we introduce an innovative probabilistic approach for selecting the most important tags, which considers certain interesting aspects of tags,
- (iii) we provide a principal trend analysis and classify tags as landmarks and events based on the temporal distributions of their textual metadata, and
- (iv) we place the most important metadata on a map and visualize their level of importance.

At this stage it is also worth pointing out some novel aspects of this work. First of all we made a choice to deal with tags and geo-tags by utilizing fixed-size clusters. In this manner, we are sure that tags that belong to landmarks or area-specific events always end up to the same cluster. Secondly, we consider the user factor in the process, since the clusters that occur do not have predefined boundaries, but quite on the contrary we only predefine the shape of the clusters, while their centers are determined after an automatic, unsupervised approach. As already mentioned, we also propose a probabilistic framework, in order to select the most representative tags, characterized by novel notions in the modeling of tags and their spatial neighbors and also in the modeling of geo-places. All in all, this research work attempts to broaden the scope of tag-recommendation approaches by providing a broader, semantic-based view on it. Last, but not least, the herein proposed methodology is fully automated, as it demands only two user-defined parameters, i.e., the radii of geo-clusters and geo-places; a fact that to the best of our knowledge constitutes it rather unique in nature.

A last justification is required for selecting Flickr social network to base all our observations, studies and applications; Flickr was favored due to the main fact that it has been very popular during the last few years, both for being the largest collection of community collected geo-tagged photos and for offering a public Application Programming Interface (API)² for accessing these photos along with their metadata information. Each Flickr uploaded photo may contain metadata added by its photographer, such as textual tags that describe either its visual content or location, or even a free text that describes the photo from its uploader's point of view. It may also contain metadata added by the hardware equipment used to capture it or by the photographer, such as date taken, camera settings (e.g., ISO, shutter speed or aperture values), equipment type (e.g., camera, smartphone), etc.

The rest of this paper is organized as follows. In Section 2 we begin by presenting relevant recent research works on handling social media content collections, focusing on metadata available

from Flickr, as well as other online social networks, micro-blogging platforms and content collections. Then, in Section 3 we present the main aspects of our work, that may be summarized briefly in the clustering technique we apply on photos based on their geo-data, the tag-ranking algorithm we apply on each cluster and the clusters' modeling and transition to semantic “places”, as well as the definition of trends and time exploitation. Our experimental results derived from the application of discussed approach on two datasets are provided through a detailed case study in Section 4. Finally, in Section 5 we briefly discuss our future plans.

2. Related work

2.1. Exploiting information

As expected, the tasks of semantically characterize, organize and efficiently exploit user-generated multimedia content towards the meaningful exploitation of its carrying information are of great importance within recent research community efforts. Starting back in 2009, Cha et al. [12] collected and analyzed large-scale traces of information dissemination derived from Flickr, aiming at answering a set of information propagation questions. More recently, Kalantidis et al. [28] proposed a visual-based photo image retrieval and localization approach, which exploited low-level image characteristics similarities in order to achieve accurate results. Another interesting approach is [34], where meaningful travel route recommendations are proposed, utilizing Flickr's user histories and past actions behaviors. Still, other approaches focus on mobile platforms and try to investigate whether knowledge extracted from massive content user contribution and interaction may offer any kind of added-value services [64].

Lately, research interest has been given also on statistical approaches to the problem, i.e., Yang et al. [59] developed a k-spectral centroid clustering algorithm in 2011, so as to identify temporal patterns in online media. Huberman et al. [24] studied the social interactions on the famous social microblogging network Twitter, and came to the conclusion that the underlying driving usage process is a sparse hidden network of friends and followers, while most of the links represent meaningless interactions. The almost real-time nature of information exchange inherent within this social medium constitutes it as the ideal candidate for related trend research, so Java et al. [26] investigated its social structures and managed to isolate different types of user intentions, whereas the same social network has been also examined later on by Jansen et al. [25] as a mechanism for word-of-mouth advertising.

In an effort to address and overcome some of these issues that hinder effective content access and interaction, researchers have focused on the notion of *collective intelligence*, [19] trying to identify potential sources of knowledge that would lead to efficient multimedia content characterization and thus, manipulation. Towards this direction, the addition of the notion of collectiveness aids the overall pattern deviation and complexity increase, considering all possible differentiations in interactions between small or larger groups of people. Given the fact that online user-generated multimedia content is increasingly popular, several research methods for organizing and providing access to its data have been emerged on this topic since the last few years, constituting the fulfillment of our motivation an extremely intriguing research task.

2.2. Exploiting traditional image analysis techniques

In the seek of efficient social media photo content analysis many research works exploit the fact that good, old traditional visual content image analysis may indeed provide a rather powerful description. As a

² <http://www.flickr.com/api>

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