# City Exploration by use of Spatio-temporal Analysis and Clustering of User Contributed Photos

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## ABSTRACT

We present a technical demonstration of an online city exploration application that helps users identify interesting spots in a city by use of spatio-temporal analysis and clustering of user contributed photos. Our framework analyzes the spatial distribution of large city-centered collections of user contributed photos at different time scales in order to index the most popular spots of a city in a time-aware manner. Subsequently, the photo sets belonging to the same spatio-temporal context are clustered in order to extract representative photos for each spot. The resulting application enables users to obtain flexible summaries of the most important spots in a city given a *temporal slice* (time of the day, month, season). The demonstration will be based on a photo dataset covering major European cities.

## Categories and Subject Descriptors

H.3.1 [**Information Storage and Retrieval**]: Content Analysis and Indexing - Algorithms

## General Terms

Algorithms, Experimentation

## Keywords

Clustering, spatio-temporal mining, landmark/event detection, content browsing

## 1. INTRODUCTION

The rising popularity of photo sharing applications over the Web has led to the generation and online availability of huge amounts of pictorial content. Several studies have demonstrated the value of such content for the discovery of landmarks and events in a place [7, 9, 10], as well as for the extraction of travel itineraries [3, 5, 8]. However, these studies have largely disregarded or under-exploited the temporal aspect of social media content. In fact, depending on the time considered, the interesting spots and events in a place may change significantly. In addition, content analysis should consider different temporal scales, e.g. time of the day, month, season. In this demo, we leverage the spatio-temporal aspects of social media content in order to improve the content browsing and exploration experience.

Our demo builds upon ClustTour [6], an online city exploration application that uses photo clusters corresponding to landmarks and events in order to assist content browsing. In this demo, we add a layer of spatio-temporal content organization that further improves the content consumption experience. More specifically, for each place (e.g. city) we identify a set of key temporal contexts (e.g. daytime/nightime, April, summer), and we present users with the option of viewing the most important areas of interest of a place, given the selected temporal context. For each area, we provide a cluster-based view over the contained photos, presenting one representative photo for each cluster. In this way, users can easily explore the interesting spots of a city and understand its dynamics.


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## 2. RELATED WORK

Since the wide success of social media applications, such as Flickr and YouTube, there has been growing interest in methods for automatically mining landmarks and events from large-scale social media content sources. For instance, the work in [10] deal with the problem of landmark recognition, while the work in [1] address the problem of event detection in social media. Few studies consider the identification of event and place semantics as parts of the same problem [7, 9]. However, the aforementioned studies make limited use of the temporal aspects of social media content. Crandall et al. [2] make use of the photos' timestamps in order to improve the accuracy of their automatic photo positioning scheme. Furthermore, the works in [3, 5, 8] mine the temporal information of large photo collections in order to discover within-city trips, i.e. sequences of point of interest visits. Girardin et al. [4] performed a spatio-temporal analysis of the digital footprints of people in Rome with the goal of uncovering the population dynamics in the city. However, to our knowledge there has been currently no work exploiting the spatio-temporal characteristics of user generated photo collections for information retrieval purposes, i.e. to present users with novel means of exploring massive place-centered photo collections.

## 3. DEMONSTRATION

The demo builds upon our existing application ClustTour[1] [6], which uses photo clusters corresponding to landmarks and events in order to assist the online exploration of a city. A list of 25 cities is currently covered by the demo. ClustTour provides a means of alleviating information overload, by providing a cluster-based view over very large collections of geotagged photos. By use of the framework in [7], photos are organized into clusters, and photo clusters are classified as landmarks and events. Subsequently, ClustTour uses a map interface to visualize clusters and to enable users to navigate through them. The application offers two modes of exploration: a city view depicting a high-level view of the most important clusters in the city (ranked by number of photos contained in them) and a Point of Interest (PoI) view centered on the selected PoI and showing landmarks and events in its vicinity.

The proposed demo extends ClustTour in two ways: (a) it provides a spatio-temporal content organization layer on top of the photo clusters, and (b) it refines the clusters detected by the framework in [7] by taking into account the spatio-temporal distribution of photos in the dataset. In that way, the demo endows users with enhanced content exploration and browsing capabilities, and at the same time, it improves upon the quality of the presented clusters. In the end, users will get informative views over the interesting spots and areas in a city depending on the temporal context that is of interest to them. Figure 1 provides an illustration of the envisioned User Interface of the demo.

The spatio-temporal organization layer is implemented by providing users with a set of "time slice" facets that they can select in order to obtain a summarized view of the interesting areas in a place. For instance, it will be possible to see what are the top 20 areas in a city during night hours (useful for people seeking for nightlife spots) or the top 20 areas during summer (useful for people planning a summer visit in the place). A predefined set of "time slices" will be supported in order to make the computational aspects of the problem manageable. The spatial organization of content is supported by use of the fuzzy notion of "areas" as mentioned above. Areas will be defined based on the results of spatial clustering on the geographic information of user generated photos. Depending on the observed spatial distribution, areas can range from single landmarks (e.g. Eiffel Tower in Paris) to neighborhoods (e.g. Poblenou in Barcelona). Compared to the existing marker-based representation of PoIs in ClustTour, the proposed demo will rely on a polygon-based PoI representation that is more informative and depicts the geographical characteristics of a PoI more accurately.

The cluster quality refinement compared to ClustTour will be achieved by incorporating spatio-temporal information in the clustering framework. In [7], photo clustering by use of visual and textual similarities between photos was applied on the whole photo collection of a city. This resulted in the extraction of some *mixed-topic* clusters, i.e. clusters containing photos from more than one landmark. In the proposed demo, photo clustering will be applied at the level of an area, thus leading to fine-grained clusters of more coherent content. The resulting clusters will correspond to representative views or spots of a particular area.

[1]Available online at: `http://www.clusttour.gr`

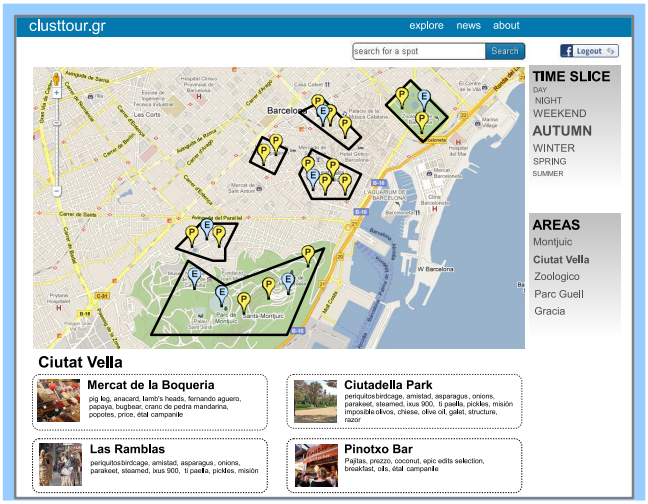


**Figure 1: User Interface of proposed demo**

## 4. ACKNOWLEDGMENTS

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