Automatic GEO-MASHUP generation of outdoor activities

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ABSTRACT
In this paper, we describe a novel approach for the automatic generation of a GEO-MASHUP related to a user his outdoor activities. Each mashup consists of online geotagged media resources related to the geographic keypoints where the outdoor activity was performed. In order to detect candidate keypoints, we search low-activity locations based on the travelling distance over time. Subsequently, we filter out route-specific keypoints (such as traffic lights) using online trajectory information. Finally, the remaining keypoints are fed to a set of social media web services to retrieve the geotagged media which summarizes the user's activity. The GEO-MASHUP demonstrator, which is evaluated in real-world conditions, shows the feasibility of our novel approach.

Categories and Subject Descriptors
H.3.5 [Information storage and retrieval]: Online Information Services – web-based services. I.5.4 [Pattern recognition]: Applications – signal processing.

General Terms
Algorithms, Measurement, Performance, Experimentation.

Keywords
Geotagging, mashups, mobile sensing, GIS, media retrieval.

1. INTRODUCTION
The beginning of the 21st century is characterized by a mobile sensing (r)evolution (Srivastava et al., 2012). Mobile phones have increasingly evolved in functionality, features and capability and are being used by many for more than just communication. With the continuous improvement in sensor technology built into these devices, people are able to create, record, analyze and share information about their daily activities or the places they visit.

Another remarkable trend of the last years is geotagging. The geotag is a form of metadata which marks a multimedia object, such as an image, video or text message, with its location information (longitude and latitude coordinates). The majority of recent capture devices are able to automatically assign geotags.

The huge benefit of geotagged media, is that it allows multimedia objects to be browsed and arranged geographically. Photo-sharing websites, for example. such as Flickr (www.flickr.com) and Panoramio (www.panoramio.com) provide millions of geotagged images contributed by people from all over the world.

In our work, we combine the mobile sensing with the geotagged media in a unique way. The proposed GEO-MASHUP automatically selects online geotagged media related to the activity that someone has performed, taking into account the route statistics of the activity. In this way, for example, it is possible to automatically generate a personalized multimedia summary of a tourist visit to a city in case someone has forgotten his camera.

The remainder of this paper is organized as follows. Section 2 presents the related work in mobile-sensing and geotagged media retrieval. Subsequently, Section 3 proposes our novel GEO-MASHUP architecture, of which the general scheme is illustrated in Figure 1. Next, Section 4 presents the demonstrator and its evaluation results. Finally, Section 5 lists the conclusions.

2. RELATED WORK
With the growing availability of geo-related web services, it is possible to achieve a unique combination of multimedia objects of different origin coupled to someone's location coordinates. In this section, we will briefly discuss the related work in this domain.

Hariharan et al. (2005) describe several applications that take advantage of existing Web data combined with location measurements from a GPS receiver. Pinpoint Search, for example, converts the (latitude, longitude) pair of a location into search terms for a search engine, giving web pages relevant to the user's immediate surroundings, i.e., an example of the 'geographic web'.

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Figure 1. General scheme of the proposed GEO-MASHUP architecture.

In (Van Canneyt et al., 2012) it is shown how the large amount of geotagged data in social media can be used to complement existing place databases. A similar study is performed by Mamey et al. (2010), in which they provide Flickr based recommendations of current city hotspots. Both works focus on how geotagged media can be used to find key locations. To the best of our knowledge, we are the first taking the opposite approach, i.e., finding media for user-specific location keypoints.

3. GEO-MASHUP GENERATION

As shown in Figure 1, the GEO-MASHUP architecture consists of four building blocks. The sensor data logging, i.e., the first block, is performed using an in-house Android app, which each five seconds logs the GPS coordinates, the accelerometer data and the smartphone status (Verstockt et al., 2013). Next, the second block extracts the user-specific route keypoints, i.e. locations of low-activity (as described more in detail in Section 3.1). The following block then uses the coordinates of these keypoints to perform a geotagged media search by popular social media web services (as discussed in Section 3.2). Finally, the retrieved media objects are combined in a personalized route mashup, i.e., the GEO-MASHUP of the user's activity.

3.1 Keypoint extraction

In order to extract the relevant geographic locations of someone's logged activity, we first perform a time-distance analysis on the logged sensor data. 'Candidate keypoints' are defined as locations of low activity, i.e., points with a travelling distance (*d*) below 1m in a 5-seconds time period (*t*). Instead of this fixed threshold, it is also possible to use the minimum or the local minima of *d*. In the example in Figure 2, two candidate keypoints are found.

In the next step, we further analyze the candidate keypoints to remove route-specific keypoints, such as traffic lights and (rail) crossings. In order to find this route-specific information we use the XAPI OpenMapquestAPI, i.e., an extended OpenStreetMap (OSM) API that provides enhanced search and querying capabilities. The XAPI query can be defined by OSM tags (~ route features) and/a geographic bounding box, as shown in the *XAPI example*. If XAPI can find particular route features within the bounding box, we decrease the probability of our candidate keypoint.

XAPI example:
http://open.mapquestapi.com/xapi/api/0.6/node[railway =crossing][bbox=***long****-0.001*,***lat****-0.001*,***long****+0.001*,***lat****+0.001*]

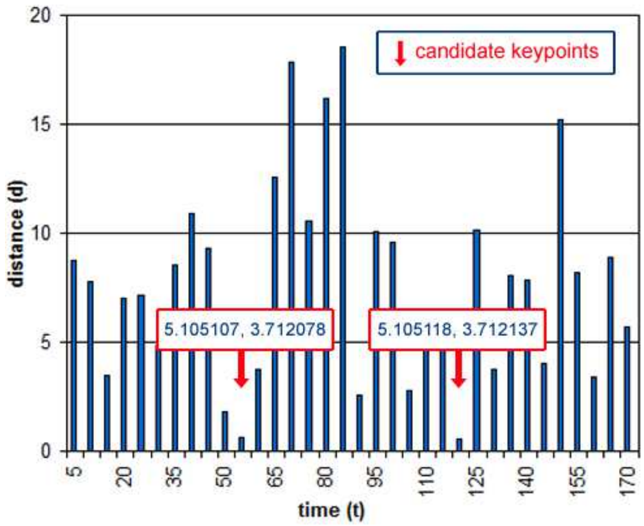

Figure 2. Detection of candidate keypoints based on travelling distance (d) in a 5-seconds time period (t).

It is important to mention that we can also take into account other users' keypoints, which on their turn can increase the probability of a candididate keypoint if they are located nearby. In the end, it is the responsibility of the application developer to decide which 'features' will influence the probability score of the candidate keypoints. When finished, the candidate keypoints with highest probability are selected to participate in the geotagged media search, i.e., the next building block in the proposed architecture.

3.2 Geotagged media search

In order to retrieve the multimedia data (i.e., images, video, text, and music) that is related to the location of the selected keypoints, we fed the keypoints' coordinates to a set of social media web services that support geo-based queries. Two of these services are described further on, i.e., our geo-based DBPEDIA flickr service and a PANORAMIO geo-picture service. However, it should be clear that the proposed approach is not limited to these examples.

3.2.1 DBpedia Flickr service

The DBpedia flickr service is split up in 2 steps. First we extract relevant DBpedia entities using a location-based SPARQL query:

<u>*DBpedia SPARQL query*</u>:
PREFIX geo:
<http://www.w3.org/2003/01/geo/wgs84_pos#>
SELECT * WHERE {
  ?s geo:lat ?lat . ?s geo:long ?long .
  FILTER(?long > ***long****-0.001* && ?long < ***long****+0.001* &&
        ?lat > ***lat****-0.001* && ?lat < ***lat****+0,001*) .
}

In the second step, we use the retrieved DBpedia entities as parameters in a query to the FlickrWrappr service of Becker and Bizer (2009). The flickr wrappr extends DBpedia with RDF links to Flickr photos. The result of this query is shown in Figure 3.

<u>*FlickrWrappr DBpedia query*</u>:
http://wifo5-03.informatik.uni-mannheim.de/flickrwrappr/photos/***DBPEDIA_entity***

Figure 3. Exemplary results of DBpedia Flickr query

The FlickrWrappr also supports pure geographic queries. In this case, no DBpedia search is performed and the results correspond to the Flickr world map. As shown in the FlickrWrappr GEO example, the *lat*, *long* and *radius* need to be defined as query parameters. The result of this query is shown in Figure 4.

<u>*FlickrWrappr GEO query*</u>:
http://wifo5-03.informatik.uni-mannheim.de/flickrwrappr/page/photosDepictingLocation/***lat***/***long***/***radius***

Figure 4. Exemplary results of FlickrWrappr GEO query

3.2.2 hpGLOE PANORAMIO service

Similarly to the FlickrWrappr GEO example, the hpGLOE PANORAMIA service is a pure geographic query. The hpGLOE query returns a JSON result, from which the relevant multimedia files can be collected online, as shown in Figure 5.

<u>*hpGLOE PANORAMIO query*</u>:
http://www.hpgloe.com/json/getrec/?lat=***lat***&lon=***long***&radius=***radius***

Figure 5. Exemplary hpGLOE PANORAMIO query

4. DEMO & EVALUATION

In order to evaluate the proposed architecture we have performed several biking and hiking tours in rural and urban environments. During these tours we collected the smartphone sensor data and stopped/slowed down at several points of interest (POI). Since it is necessary to have ground truth (GT) data to which we can evaluate our GEO-MASHUP results, the POIs were also manually annotated during each of these demo tours. These annotations consist of the location and POI type, e.g. statue, fountain, square. As such, evaluation can be done on both the localization aspect and the multimedia relevance of the detected keypoints.

For the moment, only a subjective evaluation has been performed, in which we compare the GT to the results of the geotagged media search. In order to do this comparison we use the GEO-MASHUP demonstrator seen in Figure 6. Preliminary results show that the proposed approach is able to detect the relevant route keypoints and to collect related multimedia. However, in order to strengthen this hypothesis, future work will focus on the objective evaluation of the GEO query results against the GT.

Figure 6. GEO-MASHUP demonstrator

5. CONCLUSIONS

In this paper, we have presented the detailed architecture, implementation and demonstration of a novel approach for the automatic generation of a geographic mashup related to a user his outdoor activities. The proposed architecture combines mobile sensing with geotagged media search in a unique way, i.e., the proposed GEO-MASHUP automatically selects online geotagged media related to the activity that someone has performed, taking into account the route statistics of the activity. In order to detect relevant route keypoints, we search low-activity points based on the travelling distance over time and filter out route-specific keypoints using online trajectory information. Finally, the remaining keypoints are fed to a set of social media web services to retrieve the geotagged media which summarizes the user's activity. The GEO-MASHUP demonstrator, which is evaluated in real-world conditions, shows the feasibility of our novel approach.

Future work will focus on a more objective evaluation of the proposed approach. Furthermore, we will try to improve GEO-based music search, in order to automatically retrieve music that, for example, is related to the tempo of the user and the keypoint location or landscape. Similar work is already presented in (Braunhofer et al., 2013), however, the proposed 'Bluebrain' location-aware music albums are targeted to one specific place and music selection is not done automatically.

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