On the use of geotagged photographs and GIS analysis for detecting travel patterns in protected areas

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Introduction

Knowing the distribution and flows of visitors is essential to the management of protected areas. It enables park managers to assess use levels and eventually determine whether and where standards of quality are violated. The task is particularly challenging when the size of the protected area is considerably large and potential visitor routes are several. In such a case most traditional monitoring techniques (e.g. direct observation, mechanical counters), requiring extensive field work and personnel's effort, fall short of providing a reasonably cheap and immediate support (Cessford and Muhar, 2003). Simulation models, though powerful, call for complex computer programming and intensive data collection for model calibration (Cole and Daniel, 2003). Recently, the advent of the Web 2.0, enabling people to easily share digital material (e.g. photos, videos, GPS routes, etc.), has provided a new source of information about people's movements. In particular, geotagged photographs are georeferenced images that are uploaded on popular map-based websites (e.g. Flickr, Panoramio) by their authors. Considering that details like the name of the author and the date are attached to every image, it is possible to identify the most popular spots and track people's movements within a given area. Various authors (Girardin et al., 2008; Jankowski et al., 2010) have taken advantage of these features to detect popular locations and main tourist flows in highly visited regions and cities. However, their approach is not really informative in the case of natural area management because it simply quantifies visitor flows from one popular location to another without specifying which exact routes are followed. This study introduces a novel methodology combining the analysis of geotagged photographs for identifying popular destinations and GIS analysis for estimating visitor flows. The study was conducted on the recently established Dolomites Unesco Heritage site, in northeastern Italy.

Method

In transportation planning, traffic volumes are commonly quantified by means of gravity models. These models rest on the assumption that traffic between two points is proportional to the amount of activity at each point and inversely proportional to the distance between them. The movement of visitors within a natural area generally follows this rule. People tend to move from some access points (e.g. village, trailhead, bus stop) to some destination points (e.g. natural attraction, campground, hut) and the volume of such movement is somehow proportional to the attractiveness of points, and inversely proportional to the distance between those (Figure 1). Distance in this case should not be strictly intended as a geographical measure, but rather as the "cost" in terms of fatigue, danger, chance of nice views, etc. for reaching the destination from the access point.

Identification of access and destination points

Access points are places where people start their excursion: for a matter of simplicity these were identified as main roads and cable car stations. It was assumed that a destination point is one where the density of geotagged photographs is particularly high. A total of about 4000 photographs taken between June 1st and September 30th in the years 2000-2011 were analyzed and their location and data recorded in GIS raster format. Density was computed by applying a 300m x 300m moving filter, which assigned each cell the number of photographs taken within the filter on different days. Another filter (1000m x 1000m of size) was then applied on the density map to extract pixels of high density, representing destination points.

Gravity model

The level of attractiveness was measured as the expected number of visitors and the number of photographs for access and destination points, respectively (Figure 1). In particular, the number of visitors was derived from the number of hotel beds in the surrounding of a given access point. The distance factor was assessed for each pixel as the travel time for going from the closest access point to the closest destination point (Figure 1). This was done by means of GIS weighted distance calculation functions. Constants of the gravity model were then estimated by considering actual numbers of visitors, as measured by mechanical counters at some locations across the study area.

Results and discussion

The primary result of this analysis is a map reporting the expected level of crowding on each section of a path network. While numbers in the map do not reflect real numbers, they provide a detailed picture of expected visitor flows. This would enable park managers to quickly determine which parts of a natural area are overcrowded and therefore activate proper measures to redirect visitor flows so that standards of quality are met. The main advantage of the proposed methodology is related to its simplicity and minimal requirement of data from the field. Thus, it is highly suitable for large natural areas with extensive path networks, where on-the-ground data collection would be expensive and time-consuming. However, the method rests on various assumptions (e.g. visitor flows are determined on the basis of nearest access and destination points only), which make it particularly weak in case complex patterns occur in the real world (e.g. several popular destinations close to each other, multiple paths joining into one). A crucial issue in the analysis of geotagged photographs is related to the accuracy of the georeference. Very often, especially in the presence of popular landmarks (e.g. famous mountains), photographs are not located where they were actu-

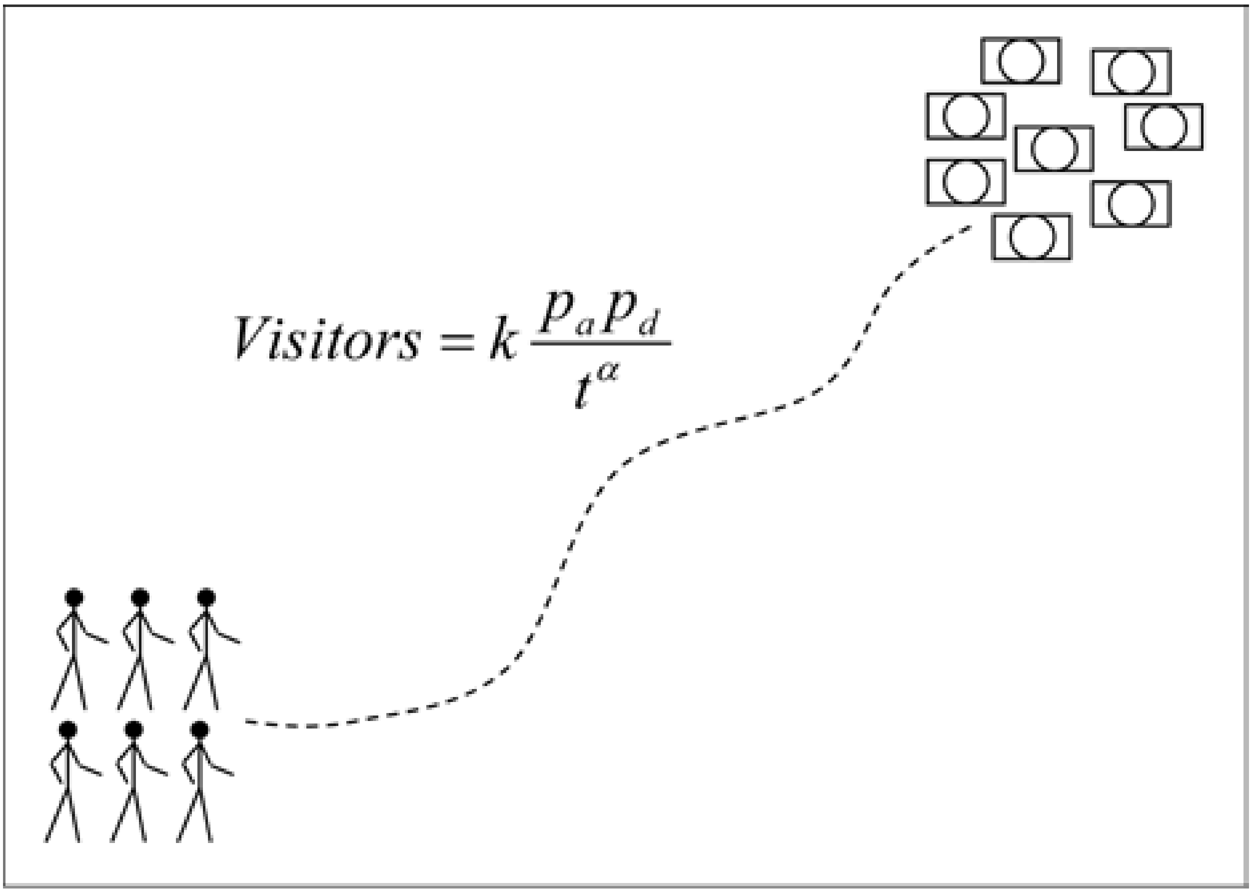

Figure 1. The number of visitors moving on a path is assumed to be proportional to the population at the starting point and the popularity of the destination point (as measured by density of geotagged photographs), and inversely proportional to the travel time between those points, by means of constants k and α.

ally taken but where the portrayed subject is. The use of automatic photo downloading procedures in this case may overestimate the popularity of a place by counting also photographs that may have been taken kilometers away from the place itself.

Ultimately, the map obtained from this analysis provides relevant information about the opportunities for solitude offered by a given region. When combined with information on remoteness, disturbance and naturalness, it may support wilderness mapping of areas whose limited size (hundreds of square kilometers) implies that solitude opportunities are represented through actual people's travel patterns.

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