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Visualisation and analysis of landscape change using crowdsourced historical photographs

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Mountain areas have been subject to the effects of human activities that are either direct (e.g. construction of infrastructures) or indirect (e.g. global warming). In order to understand these effects, it is important to offer tools to monitor and analyze the variations during a period of time. These variations are very slow at the time scale of a human being. Hence, there is also the need of showing and communicating these changes to the public and to exhibit the impact of for instance climate change and land planning policies.

Currently, mainly two types of remote sensing data are used to monitor landscape change in mountainous environments: 1) satellite images but the first images were shot in 1972 and had a very rough spatial resolution. 2) Photogrammetric survey started in 1915 in Switzerland, they are used to generate 3D models or orthophotos. On the other hand, photographs of mountain areas exist since the middle of the 19th century and are precise snapshots of the landscape. Unlike most of the photogrammetric images which are top views, photographs are shot with an oblique point of view which is closer to our natural viewpoint. Generally, photographs can not be processed with state of the art photogrammetric software. In Switzerland, Bozzini and Produit have developped a system to compute the location of a single photograph and extract geographic information from it. However collections of photographs remain an underused medium since they are a) often not available in a digitized form b) often stored in disseminated archives that are not easily accessible to researchers c) lack a georeference.

Scientists are mostly interested in metrics of landscape change such as measuring the extent of a natural disaster or the evolution of an area. However, to communicate the landscape variation to the general public the visualization of the variation is sufficient. *swisstopo* provides a web map which shows the evolution through topographic maps. *Google earth engine* uses satellite images to show time-lapses, but it is limited by the quality of past satellite images. Many authors prefer photographs to show changes, because they are closer to our real view. An common method is called rephotography which is a repeated photograph of a historical photograph. Both images can be overlaid and easily compared. This method is widely used in books and web sites. It has the advantage of showing the variation with a natural viewpoint.

The goal of our web platform smapshot is to 1) group disseminated collections in a single platform 2) compute the exact location and orientation of photographs 3) provide a virtual globe to show the landscape variation in mountainous areas through photographs.

Federate collections: smapshot gathers private and public collections of landscape photographs and stores these photos in an efficient geographic search engine. Hence, we ease the access to landscape photographs for both the general public and professionals.

Figure 1. Post card inserted in the virtual globe. Source: Fond Perrochet, ACM-EPFL

Georeferencing: smapshot uses crowdsourcing to find the exact location and orientation of the photographs. To accomplish this goal, we developed a web-based 3D georeferencer. This module computes the photograph location and orientation based on corresponding points where a volunteer clicks in the photograph and in a virtual globe.
The exact location and orientation enables us to compute the points of interest which are visible in the photographs. This information is delivered to the archivists who use it to enrich their collections.

Virtual globe: Finally, the photographs are placed in a virtual globe (Figure 1). The general public can navigate through the virtual space to compare the current virtual landscape with the photographs.

The prototype is currently tested with collections of swiss landscape photographs. Indeed, the mountains of Switzerland have two advantages. First, the jagged horizon line eases georeferencing. Second, mountain areas show drastic changes such as the enlargement of mountain resorts and the retreat of glaciers. Our community of volunteers provides an accurate georeferencing of most of the 1500 photographs stored in the platform. Hence, we can notice that in famous areas, such as the Matterhorn region, photographs provide a continuous remote sensing of the landscape with a high spatial accuracy. This is very promising both from a geospatial scientific point of view to study the landscape evolution and from a web-design point of view to develop time-lapse modules.

In the future, we would like to develop tools dedicated to scientists and other professionals such as land planners and geographers. These tools could be used to improve the geolocation provided by the volunteers and extract accurate 2D and 3D geographic information from the photographs. Moreover machine learning algorithms can be developed and used to automatically detect and classify changes.

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