Using landscape photographs for quantitative evaluation of alpine ecosystems: automated estimation of camera parameters and orthorectification

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Alpine ecosystems are vulnerable to climate change. They show distinct features caused by specific physiological environments. The accessibility of these areas is very low. That is why remote-sensing is essential for detecting changes in alpine regions. Satellite images cannot provide enough resolution for capturing their features. An alternative way is using fixed-point cameras with high resolution. But pictures of them are quite limited temporally as well as spacially.

Photographs taken by ordinal hand-held cameras provide high ground-level resolutions. They are relatively abundant and cover a wide range of time and spatial scales. But they have rarely been used for spatial analysis of alpine ecosystems. The main difficulty is transforming image coordinates to geographical coordinates by orthorectification. If this transformation is feasible, we can build an extensive database for the quantitative evaluation of alpine ecosystems using still film and digital photos collected on the internet and those taken daily by the staff of national parks.

Here we propose an R package to estimate camera parameters (shooting positions, directions, fields of views, and lens distortions) for orthorectification of photos taken by hand-held cameras.

Steps for estimating camera parameters are as follows.

1. Building a database of terrain silhouettes using a digital elevation model (DEM).

2. Making a rough estimation of the camera parameters by matching the shape of silhouettes.

3. Generating a simulation photo using the roughly estimated parameters, DEM, and an orthorectified airborne photo.

4. Adding ground control points (GCP) on the target photo.

5. Estimating the camera parameters using GCP with a Genetic Algorithm method.

6. Orthorectification of the target photo.

For testing the performance, we used photos taken with a fixed-point camera located in Murodo-Sanso, Tateyama, northern Japanese Alps. We performed two types of orthorectification; 1. all camera parameters were unknown, and 2. the camera position and the field of view were given. Then we compared estimated geographical coordinates for each photo pixel between these two conditions. The difference in coordinates was significant in the foreground area because of the uncertainty in the estimated shooting positions.

To estimate camera parameters for foreground areas, we are now developing a machine-learning method that can extract the terrain features from arbitrary photos. It enables the orthorectification even without orthorectified airborne images. This new approach will boost researches for interpreting ecological contexts from alpine photos taken by ordinal hand-held cameras.

Keywords: Alpine ecosystems, Remote sensing, Hand-held camera

