QGIS plugin or web app? Lessons learned in the development of a 3D georeferencer.

Produit Timothée[1], Jens Ingensand[2], and Gillian Milani[3]

[1-2]University of Applied Sciences Western Switzerland, G2C Institute, Department EC+G
[3]University of Zurich, Department of Geography, Remote Sensing Laboratories

ABSTRACT

Collections of historical images are currently being scanned to stop their degradation and to enable a numeric exploitation. These collections have a high cultural, artistic and scientific value. However, they are not fully exploited because the photographs do not have a georeference (geographic information cannot be extracted from the picture) and are poorly labeled (makes searching in a database inefficient). During the last years, we developed a QGIS plugin and a web app dedicated to the georeferencing of photographs and the linking of images with spatial data. In this paper, we discuss the technologies involved and compare both implementations. The results suggest that both approaches are valuable but provide different advantages in term of target users and development effort.

Keywords: 3D georeferencer, virtual globe, camera orientation, historical images, VGI, plugin, web-application

1 INTRODUCTION

Our ongoing project focuses on a collection of historical landscape photographs. As standard remote sensing images, such as satellite or aerial imagery, these pictures record a state of the landscape. However, poor georeferencing and labeling prevents their use in Geographical Information Science. Our project is based on the paradox that precise labels are stored in spatial databases (for instance place names and land cover classes) but they are not used to label landscape images. Inversely, images record a detailed state of the landscape, but this information can't be inserted in a GIS. Indeed, to relate a picture with geographic data, the picture must be accurately oriented, i.e. the camera position, direction and field of view must be provided. These parameters are required to i) project spatial information in the image and annotate pictures accordingly ii) to project information from the image to the map iii) insert the images in a virtual globe at their exact location.

The most accurate method to compute the orientation of a single image is the mono-photogrammetry. A picture is georeferenced with Ground Control Points (GCP); points that locate visible features both in the picture (2D) and in the reference map where the altitude is extracted from a digital elevation model (DEM) Bozzini et al. (2012); Messerli and Grinsted (2014). These 2D-3D correspondences are the inputs of a camera orientation (or 2D-3D pose estimation) algorithm, which computes the unknown parameters of the camera. A slightly different approach is to use as reference a 3D environment. It provides a natural navigation and viewpoint and makes the digitization of GCP easier. Furthermore, the basic functions of a 3D environment, which recur to the graphic card power, improve the performance. The usage of a 3D environment was presented in Produit and Tuia (2012) and successfully integrated as a plugin for QGIS Milani (2014).

In this paper, we will discuss and compare the development effort, the technologies and the opportunities offered by the plugin Pic2Map for QGIS Milani (2014) and sMapShot our current web platform for the georeferencing historical photographs collection Produit and Ingensand (2016).

2 IMPLEMENTATIONS

Pic2Map was implemented as a Python QGIS plugin during a master thesis. It is dedicated to the interaction between a picture and a GIS. The plugin makes an extensive use of OpenGL, a computer graphic library, in order to create a reference 3D environment.

Based on this first experience, we are currently implementing a web platform that offers similar capabilities. The idea is to take advantage of volunteers' local knowledge in order to georeference large collections of historical images and to provide a virtual globe interface to navigate between georeferenced images. For this platform, we are focusing on the usage simplicity rather than on a large range of specialized GIS functionalities.

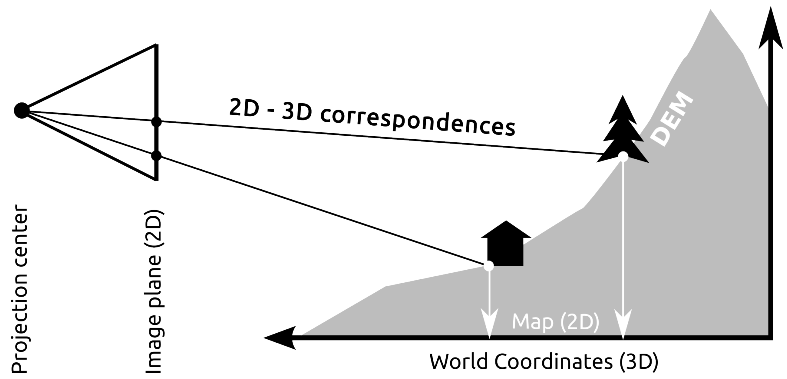

Figure 1. Perspective geometry: the camera orientation is computed from 2D-3D correspondences.

2.1 Input data

For both implementations three input files are required:

- An oblique image
- The reference layers: a DEM and an orthoimage

In Pic2Map, the user must provide each dataset. The user is free to choose the appropriate resolution according to his needs and the size limitation. In sMapShot, the virtual globe Cesium is connected to the official swiss spatial data servers. Hence, it has no restriction regarding the extent. However the proposed reference resolution is fixed.

2.2 Georeferencer

Georeferencing an oblique image correspond to finding the geometry of the image (see Figure 1). An image georeferencer interface has three main parts: the image, the reference (the virtual globe or a map) and the GCP table (see Figure 2). The task of the user is to digitize GCPs, that is, to click on similar locations in the image and virtual globe. These 2D-3D correspondences are inserted in a pose estimation algorithm, which computes the image location, orientation and field of view. Both pose estimation algorithms recur to a Gauss-Newton optimization, which solves the camera orientation parameters. The computed orientation is translated in virtual globe parameters to update the position and orientation of the virtual camera. If the GCPs are correct, the virtual viewpoint corresponds to the picture viewpoint. Hence, the space of the image coordinates is related to the space of the virtual view coordinates. In Pic2Map, the orientation and the images can be saved as a KML file and visualized in Google Earth. In sMapShot, the camera orientation is saved in a PostgreSQL/PostGIS database and a 3D model textured with the picture is stored on the server (see Figure 3).

2.3 Virtual globe

Since no 3D interface was available in QGIS, Pic2Map has its own 3D interface, which is implemented with the help of the OpenGL library. In sMapShot the 3D interface is based on Cesium which is becoming the standard open source virtual globe.

2.4 Image viewer

The image viewer in sMapShot is OpenSeaDragon. This viewer is convenient because it reads tiled images. Hence, a full resolution image is shown to the user (required to zoom in the image to digitize accurate GCP), but the original image is not sent to the client due to the fact that some image owners do not want to give access to the full resolution image.

PeerJ Preprints | https://doi.org/10.7287/peerj.preprints.2243v1 | CC BY 4.0 Open Access | rec: 5 Jul 2016, publ: 5 Jul 2016

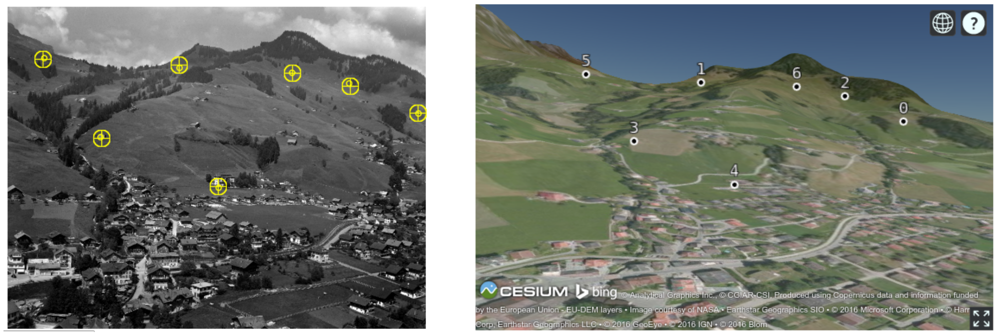

Figure 2. sMapShot: GCP are digitized in the photograph (2D) and in the virtual globe (3D).

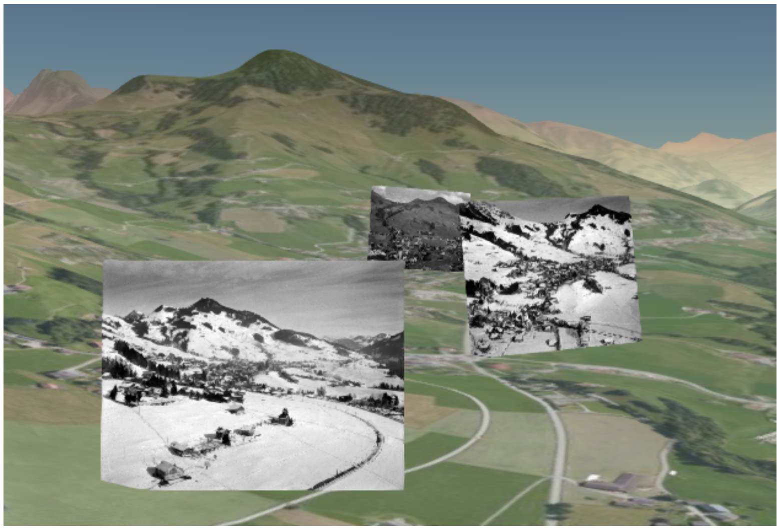

Figure 3. sMapShot: 3D models of the photographs are displayed in the virtual globe.

2.5 Image-to-map transformation

This function is used in three different scenarios. First, it is required to compute the image footprint (the polygon which encloses the area visible in the picture). Second, it transforms a click in the image in global coordinates, for instance to edit or digitize spatial data from the image. Finally, if each image pixel has a global coordinate, the image can be orthorectified. Both Pic2Map and sMapShot use a similar technique: a virtual view which has the characteristics as the picture is generated. OpenGL and Cesium provide a function to extract the global coordinates of a virtual view coordinate.

2.6 Map-to-image transformation

This function is used to overlay spatial data on the images, for instance to tag an image with place names. In Pic2Map, the user can project any point or line layers, their label and symbology. Currently, sMapShot is connected to the OpenStreetMap database and the place name (see Figure 4 and hydrology can be overlaid on the image.

3 ANALYSIS

The explosion of shared source codes and knowledge eases the development of interdisciplinary and complex software. In both projects, we make use of computer vision and computer graphics algorithms as well as photogrammetric and geographic libraries.

Both Javascript and Python have the advantage to be independent from the Operating System and do not require an installation. The loading of the script (by QGIS or the browser) is sufficient to install the software. However, OpenGL is the source of most of the bugs encountered by Pic2Map users. Indeed, it is differently supported by the operating systems and graphic cards. The web app implementation is

PeerJ Preprints | https://doi.org/10.7287/peerj.preprints.2243v1 | CC BY 4.0 Open Access | rec: 5 Jul 2016, publ: 5 Jul 2016

Figure 4. sMapShot: OpenStreetMap place names are displayed in the image.

more robust. Nevertheless, the interface adaptation for the various browsers can also be a tidy task for the developer.

The main difficulty in the implementation of Pic2Map was brought by the 3D interface in OpenGL that has to be implemented from scratch. Hopefully, QGIS will provide an integrated 3D interface and allow us to develop a more robust plugin. In the case of sMapShot, the usage of Cesium, dedicated to spatial data strongly facilitates the development. However, Cesium proposes higher-level functions than OpenGL. It is a limitation once that particular computer graphics functions, not directly related to spatial functionalities, are required (for instance texturing the DEM with an oblique image for the orthorectification).

The implementation within QGIS has also several advantages. First, the Pic2Map plugin inherits from all the basic functionalities of QGIS such as the GUI, reading and saving spatial data. Hence, Pic2Map is more dedicated to advanced users having various needs. However, the web opens new opportunities such as the creation of image databases and the involvement of volunteers in tasks, which could previously only be performed by professional users. The development of a web application must therefore focus on usability and user experience (UX).

4 CONCLUSIONS AND PERSPECTIVES

Other applications of such georeferencers have already been implemented in various fields such as mapping snow cover analysis, glacier dynamics, forest areas and landslides. Therefore, the need of 3D georeferencer as a standard function of a GIS is evident.

In a close future, sMapShot will help GIS scientists to find georeferenced historical images in their study area. However, the camera orientation provided by volunteers may not be as accurate as a georeferencing performed by a GIS specialist. Moreover, GIS specialists are more able to understand the various parameters which may improve the accuracy. Hence, we will have to decide if we want to add advanced GIS functionalities to our web app or rather focus our efforts on a more stable version of Pic2Map, depending on the target users being expert or not.

We expect that the publication of the web app will federate a community of users and developers involved in the accurate georeferencing of photographs. This community will guide us in the best choices for the future of our applications.

REFERENCES

Bozzini, C., Conedera, M., and Krebs, P. (2012). A new monoplotting tool to extract georeferenced vector data and orthorectified raster data from oblique non-metric photographs. *International Journal of Heritage in the Digital Era*, 1(3):499–518.

PeerJ Preprints | https://doi.org/10.7287/peerj.preprints.2243v1 | CC BY 4.0 Open Access | rec: 5 Jul 2016, publ: 5 Jul 2016

Messerli, A. and Grinsted, A. (2014). Image GeoRectification And Feature Tracking toolbox: ImGRAFT. *Geoscientific Instrumentation, Methods and Data Systems Discussions*, 4(2):491–513.
Milani, G. (2014). Pic2map: intégration de photographies dans QGIS.
Produit, T. and Ingensand, J. (2016). A 3d georeferencer and viewer to relate landscape pictures with VGI.
Produit, T. and Tuia, D. (2012). An open tool to register landscape oblique images and generate their synthetic model. In *Open Source Geospatial Research and Education Symposium (OGRS)*.

PeerJ Preprints | https://doi.org/10.7287/peerj.preprints.2243v1 | CC BY 4.0 Open Access | rec: 5 Jul 2016, publ: 5 Jul 2016