Unlocking airborne historical stereo-image archives for glacier elevation change assessment in Patagonia

Oral

Glaciología aplicada y tecnologías

Camilo Rada Giacaman [1], Lucas Kugler [2], Inés Dussaillant [3], Livia Piermattei [2].

(1) Universidad de Magallanes., Centro de Investigación Gaia, Antártica,, Instituto de la Patagonia, Av. Bulnes 01855, Casilla 113-D, Punta Arenas, Chile.
(2) University of Zurich, Department of Geography, 8057, Zurich, Switzerland.
(3) Centro de Investigación en Ecosistemas de la Patagonia, José de Moraleda #16, Coyhaique, Chile.

camilorada@gmail.com

Understanding long-term Earth surface processes requires consistent and temporally extensive measurements, yet such records are often scarce or incomplete. Historical aerial imagery captured by analogue cameras in the 20th century offers a unique opportunity to reconstruct past landscapes and derive digital elevation models (DEMs) to quantify glacier elevation changes.

Structure-from-Motion (SfM) photogrammetry has become a standard method for processing scanned historical aerial images. The general workflow involves the following steps: (a) image pre-processing, (b) tie-point extraction and image matching, (c) bundle adjustment, (d) georeferencing, and (e) dense point cloud reconstruction, which is then rasterised into a DEM. However, processing historical images presents significant challenges such as poor image quality due to preservation and scanning, limited metadata, geometric distortions, and non-standard acquisition geometries.

In recent years, learned models originally developed for robotics and modern computer vision have demonstrated impressive performance in feature extraction and matching tasks compared to traditional methods. Still, their applicability to historical aerial imagery remains largely underexplored, as these models were not trained with such data in mind.

This study aims to create an automated processing pipeline to reconstruct the geometry of Patagonian glaciers at a regional scale from aerial photography, including the 1944-1945 Trimetrogon flights by the US Army Air Force, and the circa 1985/1998 flights of the Chile60 and GEOTEC survey by the Servicio Aerofotogramétrico (SAF) of the Chilean Air Force.

The project is still on its early stages, and we present here an evaluation of the potential of integrating learned models into historical photogrammetric workflows to improve DEM generation and support long-term elevation change analysis. We compare the HSfM pipeline (which is primarily based on the commercial Metashape software), with an open-source alternative using SuperPoint and LightGlue for feature extraction and matching, combined with COLMAP's incremental mapper to compute a sparse reconstruction. Georeferencing is performed using the co-registration approach proposed in the HSfM pipeline, following a chain of different Iterative Closest Point (ICP) methods and the Nuth & Kääb algorithm.

Both workflows are applied to scanned historical aerial imagery from the Chile60 flight campaign (1984), reconstructing the Grand Campo Nevado Glacier in Chilean Patagonia, which we have selected as a test area. We assess the quality of the feature extractors and matchers used in the two methods by evaluating the average root mean square reprojection error after the bundle adjustment and median and quantile DEM differences on stable terrain. Additionally, the vertical accuracy of the generated DEMs is analysed by calculating the elevation difference with a reference DEM on stable terrain. For the reference DEM, we used both the Copernicus GLO-30 DEM (approximately 2015) and the Pléiades DEM from the year 2020. The latter is also used to estimate the elevation changes of Gran Campo Nevado Glacier over the past approximately 50 years.

Palabras Clave

(1) photogrametry, (2) historical images, (3) SfM, (4) Patagonia.