Geophysical Research Abstracts
Vol. 20, EGU2018-16492-1, 2018
EGU General Assembly 2018

3D Reconstruction of Volcanic Ash Plumes using Multi-Camera Computer Vision Techniques

Kieran Wood (1), Tom Richardson (1), Lucy Berthoud (1), Matt Watson (2), Helen Thomas (2), Ailsa Naismtih (2), Josh Lucas (2), and Andrew Calway (3)

(1) University of Bristol, Department of Aerospace Engineering, United Kingdom, (2) University of Bristol, Department of Earth Sciences, United Kingdom, (3) University of Bristol, Department of Computer Science, United Kingdom

Volcanoes are natural emitters of gas and ash and transmit significant amounts of material into the atmosphere. These volcanic ash plumes can travel over great distances and have significant effects on local populations and users of the affected airspace e.g. civil air traffic. Currently, ash plumes are monitored using a combination of satellite imagery and dispersion modelling, however these models can be sensitive to source terms, leading to relatively large uncertainties in both the predicted region affected by the ash plume and its density. Historically there was a zero-tolerance approach to aircraft exposure to ash, however, since the 2010 eruption of Eyjafjallajökull, there has been a change to a dosage-based scheme. Therefore, airspace managers now require a more detailed knowledge of the ash in the atmosphere to optimise flight routes; carefully balancing the costs of increased maintenance against the costs of cancellations (or re-routing), all whilst ensuring safety standards are maintained.

This study presents a method for the direct measurement of volcanic ash plume properties. The shape, drift direction, and dispersion of a plume is reconstructed in three dimensions using multi-view imagery collected from static ground-based cameras. A space carving method has been applied to the problem to estimate the total volume of the plume at each time step. By successively applying the method to sequential images, other properties such as the drift direction, ascent rate, and dispersion rate can be deduced. Due to the large distances involved in volcanic remote sensing, the method is particularly sensitive to the camera orientation, whereby misalignments on the order of one degree can lead to errors in the plume properties. This sensitivity has been analysed, and part of the presented algorithm includes a novel technique for accurately estimating the camera extrinsic orientation by comparing the real images to ones artificially created using high resolution DEM models. The DEM-based model world also serves as an excellent visualisation tool, allowing the user to interactively 'watch' the plume reconstruction from any view point.

To increase computational efficiency and minimise the false-positives caused by meteorological clouds (which appear very similar to the plume), the algorithm also makes use of the time-connectivity between images and fits a probabilistic envelope to the plume, such that only the region of sky where the plume is expected to be located is processed. This could lead to the method being applied in real time on modest computing hardware. This study considers the overall physical dimensions of the plume, however future aims are to measure the 3D internal structure and add quantitative ash concentration retrieval methods, allowing a true ash dosage to be predicted.

An example case-study data set was collected during an expedition to Volcán de Fuego in Guatemala and subsequently analysed using the method presented. Four multi-band IR cameras were positioned in local villages surrounding the volcano, such that they all had clear views of the summit and surrounding sky. Approximately 2000 images (500 per camera) were collected over 90 minutes, with at least three significant eruptions during that period.