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Small Unmanned Aerial Systems for Environmental Research – 6th Edition

The applicability of unmanned aerial systems in mountain environments

Gernot Seier(1), Wolfgang Sulzer(1), Viktor Kaufmann(2)

(1)*Department of Geography and Regional Science, University of Graz, Heinrichstraße 36, 8010 Graz, Austria; gernot.seier@uni-graz.at, wolfgang.sulzer@uni-graz.at*
(2)*Institute of Geodesy, Graz University of Technology, Steyrergasse 30, 8010 Graz, Austria; viktor.kaufmann@tugraz.at*

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ABSTRACT:

This contribution discusses the usage of unmanned aerial systems (UAS) under challenging conditions of mountain environments and is based on the articles by [1,2,3]. This abstract summarizes the mentioned studies' main outcomes and factors influencing the applicability of UAS. Although these studies differed in the survey design and the detected changes, similarities can be deduced that reflect the challenges and issues related to the application of UAS in mountain environments. Thus, this contribution does not present original data but compares outcomes that are not primarily described in the cited sources and also attempts to address more general questions of UAS applications.

Although the specific vehicles (a fixed-wing and a multi-rotary UAS) used in the studies by [1,2,3] are not representative for all possible devices, these were the first UAS that were applied at the specific sites. However, a central aspect in terms of interpreting the UAS-based results is the accuracy assessment. A rule of thumb related to the estimated achievable accuracy is known from photogrammetry, after which the errors in planimetry only slightly increase with a decreasing base-to-height ratio at a constant map scale, whereas the vertical errors increase inversely proportional with a decreasing base-to-height ratio at a constant map scale [4]. Moreover, one question relates to the reasons of uncertainties in the results. Here, all the criterions well known from aerial photogrammetry have to be considered (e.g. the survey design (survey range, imaging network geometry), the quality of the camera and the quality of the georeferencing) but in addition to that it has to be mentioned that the uncertainties of Structure from Motion-Multi-View Stereo (SfM-MVS)-based results are expected to be generally larger than in traditional aerial photogrammetry (e.g. due to the amateur cameras used) and consequently in many SfM studies a detailed description of the uncertainties is often underrepresented. Among the discussed studies also only one publication (by [3]) provides a detailed description of most relevant additional survey data (which therefore allows to better estimate discrepancies). In addition, from this example it can be concluded that the uncertainties primarily arise from known photogrammetric and georeferencing constraints and also result from the processing procedure. However, in general, detecting both the vertical and horizontal changes generally allows to fully examine the kinetics of terrain [5]. This was implemented using well-established procedures of DEM differencing and horizontal displacement calculations (using normalized cross correlation (NCC)), and the results of both approaches were finally presented in maps. NCC is an area-based image matching approach, which (similar to feature-based algorithms and a combination of these) is based on images' grey values and a sufficient contrast [6,7] and is used to calculate displacements of individual terrain features. In addition, a more general question was whether the setup and design of the selected UAS match the requirements for a geomorphological research setting (in a mountain and partially high alpine environment). The concise answer is yes. In particular it can be stated that the findings provided would not have been possible by using different techniques.

Apart from the main objective of this contribution, which is (i) the investigation of the applicability of two different and specific UAS within the thematic setting of earth surface changes in three different challenging examples representing three geomorphological environments, another aim was (ii) to deliver practical knowledge of the data accuracy and precision reached, which could be limited due to the circumstances of the sites studied and the possibly restricting survey preconditions. The outcomes of the studies in question allow to state that (i) even

in challenging site conditions the UAS and SfM photogrammetry approach performed well. The site conditions were challenging in terms of the field work and thus entailed a certain effort and even danger to life of the operating personnel, and additionally even the survey planning was challenging due to the constraints mainly related to the topography and vegetation coverage. Relating to (ii), despite the general knowledge of estimated accuracy as introduced in traditional photogrammetry, the studies delivered practical knowledge about the actually achievable accuracy and precision in a SfM-based approach. The technique of UAS and SfM photogrammetry is certainly limited and these limitations were illustrated. Thus, it can be better assessed whether a survey of earth surface landforms or changes should take advantage of using a UAS in combination with SfM photogrammetry (and how it should be designed), or whether another technique or device should rather be applied.

As UAS are applicable in mountain environments, in future, the focus should be more on the processes of covered landforms or 3D geometry. This could be the real surplus in geosciences rather than only describing and testing the technology (cf. [8]). Even though UAS seem to be more or less ubiquitously used, which includes that not only researchers use this comparably new technology, it remains to be seen whether these devices, like any new technology, are advantageous in our practical life or only succeed in scientific community (cf. [9]). Another point mentioned by [9] is to generally stay critical with new technologies and to ensure that positive usage thereof succeeds. Thus, as generally true regarding new technologies, UAS should not reflect an end in itself but should meet the people's needs. The discussed studies delivered adequate results with an acceptable risk for nearby residents and operating personnel and addresses people's needs more or less directly (e.g. with regard to the surveys caused by the flood or the landslide as opposed to the glacier surveys, which rather provide a long-term indication of environmental changes). Similar to remote sensing in general, also the hype about UAS should be rather objectively seen. One should keep in mind that remote sensing is also limited and the largest limitation is maybe that it is often overhyped and is seen as universal remedy providing all the data needed in sciences [10]. It rather should be seen what it actually is, namely, a source of information (spatial, spectral, temporal) that is hopefully economic and efficient [10]. Also, [11] stated that the democratization of SfM-based photogrammetry (although in [11] terrestrially conducted) can be seen as valuable evolution since it offers a useful technique in mountain environments. However, [12] pointed out that from the history of remote sensing it is known that potential users somewhat resist to accept new technologies and the data derived by remote sensing.

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