Investigating the impact of in-camera distortion correction on systematic deformation in photogrammetry using Structure from Motion and Unmanned Aerial Vehicle: case study in constant-pitch meandering flight design.

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Photogrammetry using Unmanned aerial vehicles (UAVs) and Structure from Motion (SfM) have significantly revolutionized geomorphic studies, which heavily rely on precise data acquisition and analysis techniques. However, the accuracy of models derived from photogrammetry using UAVs and SfM can be affected by systematic deformation, commonly known as the "doming" or "bowling" effect, arising from various factors. This study investigates the potential impact of in-camera image pre-processing, particularly distortion correction executed prior to SfM processing, onto the systematic deformation observed in Digital Elevation Models (DEMs) derived from UAV-based photogrammetry. We conducted three distinct analyses on image sets captured at three ground sample distances (GSDs) within a 100 m x 100 m flat target area using the constant-pitch meandering flight design. The in-situ data (photos and ground surveying data) was obtained by Fujita Corporation, Japan. For case 1, image distortion was corrected using embedded parameters provided by the drone manufacturer. In case 2, the image distortion was addressed using intrinsic parameters derived from SfM processing, which employed camera coordinates (measured by Real-Time Kinematic Global Navigation Satellite System, RTK-GNSS) and nine check points (measured by static positioning) for bundle adjustment. In contrast, Case 3 involved raw images with no distortion correction. Subsequently, SfM processing and DEM generation for each case were executed under two conditions: (1) camera coordinates utilized for bundle adjustment and geo-referencing; (2) camera coordinates omitted for bundle adjustment but utilized for geo-referencing. Our results demonstrated that the pre-processing in-camera undistortion does not serve as the primary cause of DEM deformation. Instead, we observed a pronounced deformation in the resultant DEMs regardless of image distortion correction, particularly the bowling shape in Case 1 and doming shape in Case 2 and Case 3 when SfM was processed under condition 2. On the other hand, the inclusion of camera coordinates (measured by RTK-GNSS) in SfM's bundle adjustment (condition 1) removed the DEM deformation regardless of image-sets and image distortion. Our findings provide valuable insights for enhancing the future application of UAV-SfM based photogrammetry, benefiting both practitioners and researchers.

Keywords: Structure from Motion (SfM), DEM deformation, doming/bowling effect, in-camera distortion correction