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## Accuracy Analysis of Photogrammetric UAV Image Blocks: Influence of Onboard RTK-GNSS and Cross Flight Patterns

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**Keywords:** self-calibration, (in)direct sensor orientation, block deformation, UAV-based RTK, cross flight pattern, sensor synchronisation

**Summary:** Unmanned aerial vehicles (UAV) are increasingly used for topographic mapping. Despite the flexibility gained when using those devices, one has to invest more effort for ground control measurements compared to conventional photogrammetric airborne data acquisition, because positioning devices on UAVs are generally less accurate. Additionally, the limited quality of employed end-user cameras asks for self-calibration, which might cause some problems as well. A good distribution of ground control points (GCPs) is not only needed to solve for the absolute orientation of the image block in the desired coordinate frame, but also to mitigate block deformation effects which are resulting mainly from remaining systematic errors in the camera calibration. In this paper recent developments in the UAV-hardware market are picked up: some providers equip fixed-wing UAVs with RTK-GNSS-enabled 2-frequency receivers and set up a processing pipeline which allows them to promise an absolute block orientation in a similar accuracy range as through traditional indirect sensor orientation. Besides the analysis of the actually obtainable accuracy, when one of those systems is used, we examine the effect different flight directions and altitudes (cross flight) have onto the bundle adjustment. To this end two test areas have been prepared and flown with a fixed-wing UAV. Results are promising: not only the absolute image orientation gets significantly enhanced when the RTK-option is used, also block deformation is reduced. However, remaining offsets originating from time synchronization or camera event triggering should be considered during flight planning. In flat terrain a cross flight pattern helps to enhance results because of better and more reliable self-calibration.

**Zusammenfassung:** Genauigkeitsuntersuchung von photogrammetrischen UAV-Bildverbänden: Einfluss von onboard RTK-GNSS und Kreuzfliegemustern. Flugroboter (unmanned aerial vehicles, UAV) werden zunehmend zur topographische Kartierung eingesetzt. Die Systeme weisen eine hohe Flexibilität auf, jedoch muss im Gegensatz zu konventionellen Befliegungen mehr Aufwand in die Erfassung von Kontrollpunkten am Boden investiert werden. Der Grund dafür liegt in der schlechteren Qualität der Positionierungslösungen auf dem Flugroboter. Hinzu kommt, dass die verwendeten Kameras eine unbekannte geometrische Stabilität haben, und die Parameter der Inneren Orientierung normalerweise nicht hinreichend genau fixiert sind. Die Folge ist, dass eine Selbstkalibrierung im Rahmen der Bündelausgleichung durchgeführt werden muss. Diese Selbstkalibrierung ist nicht in jedem Anwendungsfall zuverlässig. Eine gute Verteilung von Kontrollpunkten ist nicht nur für die Bestimmung der Lagerung des Bildverbandes notwendig sondern auch um Blockdeformationen zu verringern. Diese entstehen größtenteils durch bei der Kamerakalibrierung verbliebene systematische Fehler. In diesem Beitrag greifen wir aktuelle Entwicklungen im UAV-Markt auf: einige Hersteller rüsten ihre Geräte mit einem RTK-fähigen 2-Frequenz-GNSS-Empfänger aus und bieten einen entsprechenden Prozessierungsablauf

# Accuracy Analysis Of Photogrammetric Uav Image Blocks

**M Lipman**



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