Optimizing sensitivity of Unmanned Aerial System optical sensors for low zenith angles and cloudy conditions

Wang, Sheng; Dam-Hansen, Carsten; Zarco Tejada, Pablo J.; Thorseth, Anders; Malureanu, Radu; Bandini, Filippo; Jakobsen, Jakob; Ibrom, Andreas; Bauer-Gottwein, Peter; Garcia, Monica

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Optimizing sensitivity of Unmanned Aerial System optical sensors for low zenith angles and cloudy conditions

Sheng Wang1, Carsten Dam-Hansen2, Pablo J. Zarco Tejada3, Anders Thorseth2, Radu Malureanu2, Filippo Bandini1, Jakob Jakobsen4, Andreas Ibrum1, Peter Bauer-Gottwein1, Monica Garcia1

1. Department of Environmental Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark; 2. Department of Photonics Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark; 3. European Commission, Joint Research Centre, Directorate D - Sustainable Resources, Via E. Fermi 2749, 21027 Ispra (VA), Italy; 4. National Space Institute, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark; *corresponding author: mgarc@env.dtu.dk

Introduction

Satellite-based optical imagery cannot provide information on the land surface during cloudy periods. This issue is especially relevant for high latitudes where overcast days and low solar zenith angles are common. Current remote sensing-based models of evapotranspiration or carbon assimilation are biased towards clear sky conditions, lacking important information on biophysical processes under cloudy conditions. Unmanned Aerial System (UAS) imagery has great potential to monitor and understand surface fluxes under cloudy conditions.

Objective

UAS imagery acquired in overcast and cloudy conditions tend to present low brightness and dynamic ranges, and high signal-to-noise levels. Another problem is the influence of land cover types on the signal. For instance, over vegetated areas, even with low irradiance, saturation is reached in the near infrared, while visible channels have low brightness. An individual camera setting for each channel and light conditions can improve sensor sensitivity while preventing saturation. This study aims to optimize the camera exposure settings and radiometric corrections of a multispectral camera to produce high quality UAV imagery under low but homogeneous irradiance conditions.

Results

Laboratory calibration results

- Geometric correction
  
  Pre-calibrated geometric parameters with the accuracy of image mosaicking and the quality of the orthophoto could be improved.

Geometric parameters:

Parameter Value
- Pixel size: 5.2 μm
- Focal length: 9.6 mm

Laboratory results

- Geometric correction
  
  With pre-calibrated geometric parameters, the accuracy of image mosaicking and the quality of the orthophoto could be improved.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>8.90E+00</td>
</tr>
<tr>
<td>Xc</td>
<td>2.61E-01</td>
</tr>
<tr>
<td>Cy</td>
<td>1.67E-01</td>
</tr>
<tr>
<td>k1</td>
<td>4.15E-04</td>
</tr>
<tr>
<td>k2</td>
<td>5.09E-03</td>
</tr>
<tr>
<td>p1</td>
<td>8.54E-06</td>
</tr>
<tr>
<td>p2</td>
<td>3.71E-05</td>
</tr>
</tbody>
</table>

C1, C2, and k1, k2 are principal point offset, F, Xc, and Cy are radial distortion coefficients; p1 and p2 are the tangential distortion coefficients.

Conclusion and future work

This study provides a methodology to thoroughly radiometrically calibrate a multispectral camera for low illumination conditions. Outdoor experiments were used to assess the performance for calibration with radiance errors within ±8%. Future work will focus on using the obtained information in cloudy and overcast conditions to improve remote sensing based models of evapotranspiration or carbon assimilation.

Acknowledgement

This study was funded by the smart UAV project from Danish National Advanced Technology Foundation [125-2013-5]. Sheng Wang would like to thank the COST ACTION ES1109 (OPTIMISE), which offers a short term scientific mission to Dr. Pablo J. Zarco Tejada’s lab in Spanish National Research Council.