Solar Photovoltaic Panel and Roofing Material Detection Using Worldview-3 Imagery

Abstract

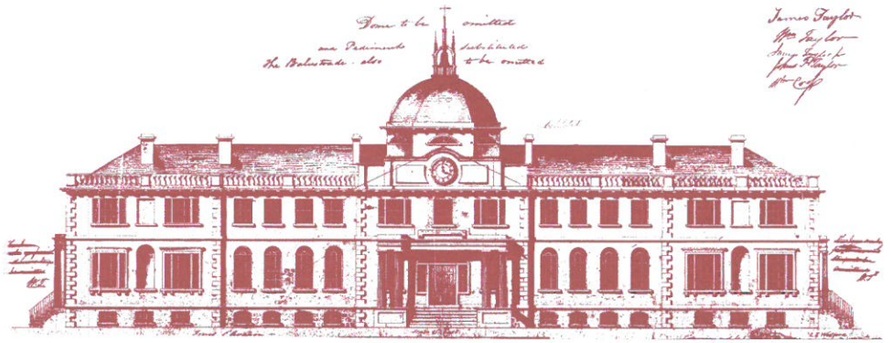
This PhD dissertation focuses on the development of new techniques to detect urban solar photovoltaic (PV) panel installations and roofing materials utilizing the commercially available WorldView-3 satellite imagery, consisting of 1 panchromatic (Pan) band with 0.3m resolution, 8 visible and near infrared (VNIR) bands with 1.2m resolution, and 8 short wave infrared (SWIR) spectral bands with 7.5m resolution. To accurately detect urban solar PV panels and roofing materials, it is necessary to analyze the spectral information in both the 8 VNIR bands and the 8 SWIR bands at the pixel level. However, the resolution difference between the VNIR bands and the SWIR bands is more than 6 times, which creates significant challenges for the spectral analysis and thus for the material detection. In order to increase the resolution of the SWIR bands from 7.5m to 1.2m, a new pan-sharpening method is developed. The resulting high resolution 1.2m SWIR bands are then combined with the original 1.2m VNIR bands to form a 16-band 1.2m (VNIR+SWIR) superspectral imagery. A method to detect solar PV panel installations and a method to detect roofing materials in the 16-band superspectral imagery are also developed.

In order to increase the resolution of WorldView-3 SWIR bands from 7.5m to 1.2m and take advantage of their capability for material identification, this research investigated the capacities of 9 popular, industry adopted pan-sharpening algorithms for pan-sharpening the WorldView-3 SWIR bands. The general principles of the pan-sharpening algorithms are reviewed. The WorldView-3 Pan images were down-sampled from 0.4m to 1.6m to fuse with the 7.5m SWIR image. Experiments demonstrate that the most commonly used algorithms are not suitable for pan-sharpening SWIR images, whereas the new pan-sharpening algorithm we developed, named Fuze Go SWIR Sharp (FGSS), can produce satisfactory results. The reasons on why most algorithms fail to produce quality pan-sharpened SWIR bands are also examined.

To detect solar PV panels, a new method is developed that can effectively analyze the spectral information in the newly formed high resolution (HR) 16-band 1.2m superspectral (SS) imagery by adapting the spectral angle mapping (SAM) algorithm. The proposed method, named HR-SSF-SAM method, is tested on the WorldView-3 imagery of Brea, California, USA. The results demonstrate a true detection rate of 93.3% with 0% false detection. Even solar PV panels and glass roofs can be differentiated from each other.

To detect roofing materials, such as fiberglass, ethylene propylene diene monomer (EPDM), metal, and concrete, using WorldView-3 imagery, a novel method is proposed. The method utilizes the newly formed high resolution 16-band 1.2m superspectral imagery and introduces a new approach to detect roofing materials. Experiments with the WorldView-3 imagery of Brea, California, USA, demonstrate that the proposed method achieves an overall accuracy of 97.59% and Kapa accuracy of 95.59% for roofing material detection in commercial areas, and an overall accuracy of 93.88 and Kapa accuracy of 88.98% for roofing material detection in residential areas with family houses.

Because of the complexity of using WorldView-3 imagery for solar PV panel detection and roofing material detection, very few publications can be found in this area. Our literature review confirms that the accuracies we achieved are significantly better those we found in the literature.



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UNIVERSITY OF NEW BRUNSWICK

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Rakesh Mishra

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Rakesh Kumar Mishra

Graduate Academic Unit

Geodesy & Geomatics Engineering

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Publications:

Mishra, R. K., & Zhang, Y. (2017). Effects of industry adopted fusion methods on pan-sharpening WorldView-3 short wave infrared (SWIR) imagery, Journal of Applied Remote Sensing – Letters (under review).

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Conference Presentations:

Mishra, R. K., & Zhang Y. (2014). Performance Evaluation of Pan-sharpening techniques on HR Satellite imagery, *ASPRS 2014 Annual Conference*, Louisville, Kentucky USA, March 23-28.

Several other Conference Presentations