Introducing a new approach for Tree detection using LiDAR data and aerial image

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Our method in five steps:

1. Preprocessing of LiDAR Data

LiDAR data are processed by detecting and removing existing noises. Eq. 1 is used to noise detection:

$$LR - FR > th1 \quad (1)$$

Where th1 is a constant value that depends on elevation precision of LiDAR points, FR and LR respectively are first and last returns of LiDAR data. Each LiDAR point satisfying Eq. 1 is separated as noise. Then noises are removed and new elevations for these points are obtained by interpolating of remaining points.

2. Off-terrain Objects Production

Digital Elevation Model (DEM) is generated from range image of last return based on Scan Labeling algorithm. Normalized Digital Surface Model (nDSM) is obtained from difference between Digital Surface Model (DSM) and DEM according to Eq. 2

$$nDSM = DSM - DEM \quad (2)$$

Then off-terrain and terrain objects are obtained by using thresholds from nDSM according to Eqs. 3 and 4.

$$off - terrain\ objects = nDSM > th2 \quad (3)$$

$$Terrain\ objects = nDSM < th3 \quad (4)$$

Where th2 and th3 are constant values.

3. Orthorectification and Co-register of Aerial Image

Co-linear equations are used to orthorectifcation of aerial images. These equations need interior and exterior orientation parameters and DSM of area. Then orthorectified image is registered using DSM of area and Rotation-Scale-Transmit (RST) method. GCPs for this registeration are selected manually from DSM.

4. New combined index production

For separating trees (and Natural Ground) from buildings, a new combined index is employed. This index is combination of new vegetable index and new shadow index.Vegetable and shadow indices respectively are obtained by Eqs. 5 and 6.

$$IRR\ RatioIndex = IR/R \tag{5}$$

$$\mathrm{ShadowIndex} = (\mathrm{G} + \mathrm{R}) \times \mathrm{G} \tag{6}$$

Where IR, R and G are respectively reflectance in infrared, red and green regions and symbol × is multiplication pixel by pixel. Shadow areas are obtained by using a threshold on shadow index according to Eq. 7

$$ShadowArea = ShadowIndex < th4 \tag{7}$$

Where th4 is a constant value. So Vegetation Areas Covered by the shadow are determined from Eqs. 8 and 9.

$$High_{IR} = IR > th5 \tag{8}$$

$$ShadowArea_V = High_{IR} \times ShadowArea \tag{9}$$

Where th5 is constant value and symbol × is multiplication pixel by pixel. Finally combined index can be obtained from Eq.10

$$CombinedIndex_{IRR} = IRR\ RatioIndex + ShadowArea_V \times IRR\ RatioIndex/2 \tag{10}$$

5.Separating buildings and trees Areas

We have used the following Equation to Separate Vegetation and non-Vegetation Areas.

$$Vegetation\ Area = CombinedIndex_{IRR} > th6 \tag{11}$$

Where th6 is constant value. Then we have detected Natural Ground and tree Areas by overlapping vegetation area respectively with the terrain and off-terrain objects according to Eqs. 12 and 13.

$$Tree\ Area = Vegetation\ Area \times Off - terrain\ objects \tag{12}$$

$$Natural\ Ground = Vegetation\ Area\ \times Terrain\ objects \tag{13}$$

Result of tree detection is improved by morphological operations. For this purpose, first an opening operation is applied to tree detection result and then a closing operation is applied to previous result.