Performance of a photogrammetric digital elevation model in a tropical montane forest environment

Abstract

Digital photogrammetry has advanced to the point where digital elevation models (DEMs) can be derived in full automation from stereo images, offering new opportunities in various fields including forestry. However, the performance and limitations of digital photogrammetry need to be carefully investigated in forest environments where both scientific studies and forest management depend on accurate information. We evaluated the performance of a photogrammetric digital surface model (photo-DSM) derived from small-format aerial photographs over approximately 2000 ha of tropical montane forest in northern Borneo, Malaysia. The accuracy of the photo-DSM was evaluated by using a reference dataset derived from airborne laser scanning (ALS) with an approximate density of 15 pulses/m 2 . The vertical accuracy over the total area (18,349,288 pixels) was represented by a mean error of 0.006 m and RMSE of 3.003 m, with 61.1% of all measured heights accurate to within ±1 m, 81.9% accurate to within ±2 m, and 88.7% accurate to within ±3 m. More detailed local accuracy evaluation was conducted at block level: 31 1-ha blocks and one 0.25-ha block located over different forest types and characterized by the mean canopy height (range=8.4–41.1 m) and standard deviation (range=2.0–9.8 m) of the ALS-canopy height model (ALS-CHM). RMSE of the forest blocks ranged from 1.01 to 4.19 m, and this variance in RMSE could be explained by 78.6% of standard deviation of the ALS-CHM. Canopy slope and dark areas also had an effect on the RMSE: in areas of higher canopy slope and in darker areas within the forest blocks, the RMSE increased by up to 8.6 and 5.8 m, respectively. No-data areas accounted for 3.24% in the forest blocks and were also influenced by canopy slope and darker areas. RMSE of non-forest areas was 0.39 m (n=5243 pixels). Research and development on image-matching algorithms (which achieved 86.1% successful alignment of the aerial photographs in our study), cameras, unmanned aerial vehicles, and flight parameters are ongoing; as a result,

digital photogrammetry and its capacity for use in various forestry applications are also continuing to improve.