Application of a consumer-grade UAV to a regional-scale estimation of the uncertainty in GNSS-based telemetry data

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GNSS-based telemetry has been used for estimating the movement patterns, home range size and resource selection of free-ranging animals. Reliability of the estimation mostly depends on the accuracy and precision of location data obtained through telemetry. Hence, it is necessary to evaluate the accuracy and precision of location data for better understanding how animals use landscapes. Since the uncertainty in telemetry data is mainly induced from GNSS signal interruption by rugged terrain and off-terrain objects such as buildings and tree canopies, Canopy Openness (CO) has been commonly used as the first-order approximation of the GNSS signal interruption probability (GNSS-SIP). However, applicability of the CO is limited in specific discrete locations where hemispherical images were taken for estimating CO. To evaluate the uncertainty in GNSS-based telemetry data obtained from free-ranging animals at arbitrary locations, a new method is needed to be developed.

This study examined the potential of a UAV-based approach to obtain spatially continuous estimation of the degree of uncertainty in GNSS locations over a regional scale. A set of high-spatial-resolution aerial images acquired from the UAV platform was used to derive a Digital Surface Model (DSM) and quasi-DSM. The DSM represents bare ground surface and includes all objects on it, while quasi-DSM is identical to the DSM except for exclusion of tree canopies. Morphometric Protection Index (MPI) was derived from the DSM. Elevation Mask (EM) was then derived from the DSM and quasi-DSM to predict the values of Geometrical Dilution of Precision (GDOP) and number of visible satellites (NSAT). The prediction of GDOP and NSAT was performed over a regional scale using the GSILIB library implemented in in-house software.

The degree of conformity of the MPI to CO was confirmed by a simple linear regression model, and the CO was successfully estimated from MPI over a broad spatial range. However, because the MPI was calculated based on the DSM, the following problems remained unsolved: (1) the CO predicted from MPI represents only the CO at top of the terrain or off-terrain objects; and (2) it cannot consider the effect of GNSS signal transmitted through an object or gaps among objects. In contrast, the GDOP and NSAT, which were derived from the DSM and quasi-DSM via the EM, were found to be capable of more properly estimating the positional accuracy and precision. This might be attributed to the fact that the GDOP and NSAT were predicted taking into account the GNSS satellites constellation and the effect of GNSS signal transmitted through a tree canopy and gaps among canopies. In conclusion, the UAV-based approach would be a promising method to estimate the degree of uncertainty in GNSS locations over a regional scale.

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