Cross-habitat transferability of segmentation models for Albanian mole-rat mound detection using UAV imagery and open-source GIS tools

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Abstract

In our study, we evaluated the transferability of a deep learning-based image segmentation model and quantified the amount of fine-tuning data required across two habitats of the lesser blind mole-rat in Albania. The first study site (Cajupi) is located in a small basin within Zagoria Nature Park. The second study site (Trebeshina) is located in the Trebeshina Mountain. Both habitats were surveyed using a quadcopter producing true-colour orthomosaics with a mean spatial resolution of 0.02 m/pixel.

The Cajupi site was used as the primary training area to develop an optimised model for detecting mole-rat mounds. A total of 925 mound polygons were delineated within a 100 × 100 m sample area. Using this training dataset, a deep learning model was trained to segment mole-rat mounds.

The resulting base model and its fine-tuned versions were subsequently evaluated at the Trebeshina site. Both the independent test area and the area used for collecting fine-tuning data had the same extent as in Cajupi. Owing to the lower mound density in Trebeshina, fewer polygons were available for fine-tuning and testing (258 and 241, respectively). The fine-tuning dataset was divided into five subsets containing increasing numbers of polygons, from 50 to 258 in increments of 50. Polygons for each subset were selected using spatially stratified sampling. Finally, the first base model was evaluated on the independent Trebeshina test datasets. In addition, the base model was also fine-tuned using each of the five subsets to assess how the amount of fine-tuning data affects segmentation accuracy.

Classification performance was evaluated using recall and precision. The base model achieved the lowest performance (R = 0.101, P = 0.044), reflecting its optimisation for the Cajupi site. The performance of the fine-tuned models improved consistently with the increasing number of polygons, from R = 0.095, P = 0.885 to R = 0.728, P = 0.863. Increasing the training dataset to total of 258 polygons resulted in only a slight improvement (R = 0.798, P = 0.888). The increase in recall indicates a higher number of correctly detected mounds, while the consistently high precision suggests that only a small number of false positives were introduced.

Our results demonstrate that transferring a deep learning segmentation model between habitats is feasible, even when differences exist in mound colour.

Keywords

mole-rat, habitat mapping, image segmentation, UAV imaging, U-Net++, Albania