Environmental Computational Science
and Earth Observation Laboratory

Master thesis subject

Large-scale Bird Detection in Aerial Imagery using Machine and Deep Learning

Context

Understanding the migratory pattern of geese provides valuable insights into habitat and environmental preferences and requirements, shifts with respect to climate change, and measures towards population control in nesting sites. To this end, expansive efforts are pursued to detect and track individual birds, for example by equipping individual birds with GPS collars and tracking their position (Belyaev et al., 2020), or by conducting population size estimates (Callaghan et al., 2021). For the latter, very high-resolution aerial images from drones and airplanes have recently opened up new possibilities to perform highly accurate estimates over vast areas. However, covering a single breeding location completely results in thousands of images and attempting to localise individual birds by hand therein is a prohibitively expensive task (Fig. 1).

Fig. 1: Example aerial image (©USGS), with a crop containing annotations for individuals, colour-coded for goose species.

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To overcome the tedium of manual identification, works increasingly employ machine learning (ML) methods that can automatically localise individuals without making errors due to fatigue. Recent works have shown promising results for automated bird recognition in aerial imagery (Kellenberger et al., 2021), but the expert knowledge required to use ML so far prevented wide-spread usage of such models. User-friendly ML software has been proposed recently, such as the AIDE annotation software that allows training deep learning (DL) models interactively on the images at hand (Kellenberger et al., 2020). However, the performance of such systems is limited unless they can be pre-trained on the images.
In this project the MSc student will investigate the possibilities of training DL models on aerial images for geese detection, acquired by the USGS. In a first step, the student will examine the data to get familiarised with the images (around 100'000 across three years, with different resolutions) and available annotations (around 10'000 annotated images). Then, he or she will extend and use an available code base to train DL-based detection models, such as Faster R-CNN (Ren et al., 2015) or RetinaNet (Lin et al., 2017), on a subset of the images, including proper experimental setup and detection performance assessment. In a final step, this model can then be integrated into AIDE and used as a high-performance starting point for future image acquisitions.

Objectives

- Familiarise with DL models for object detection by building on an existing code base
- Construct a training and evaluation workflow and train different models
- Use the best-performing model(s) for prediction of the unlabelled images and integration into the AIDE annotation software

Requirements and practical info

- Programming skills in Python are required
- Background in machine/deep learning is welcome
- The thesis will be supervised from the Sion campus
- Access to parallel computing resources is provided

Literature

- Belyaev, M.Y., Volkov, O.N., Solomina, O.N., Weppler, J., Müller, U., Tertitski, G.M., Wikelski, M. and Pitz, W., 2020, May. Development of technology for monitoring animal migration on Earth using scientific equipment on the ISS RS. In 2020 27th Saint Petersburg International Conference on Integrated Navigation Systems (ICINS) (pp. 1-7). IEEE.
- Callaghan, C.T., Nakagawa, S. and Cornwell, W.K., 2021. Global abundance estimates for 9,700 bird species. Proceedings of the National Academy of Sciences, 118(21).
- Kellenberger, B., Tuia, D. and Morris, D., 2020. AIDE: Accelerating image-based ecological surveys with interactive machine learning. Methods in Ecology and Evolution, 11(12), pp.1716-1727.
- Kellenberger, B., Veen, T., Folmer, E. and Tuia, D., 2021. 21 000 birds in 4.5 h: efficient large-scale seabird detection with machine learning. Remote Sensing in Ecology and Conservation.
- Lin, T.Y., Goyal, P., Girshick, R., He, K. and Dollár, P., 2017. Focal loss for dense object detection. In Proceedings of the IEEE international conference on computer vision (pp. 2980-2988).
- Ren, S., He, K., Girshick, R. and Sun, J., 2015. Faster R-CNN: Towards real-time object detection with region proposal networks. Advances in neural information processing systems, 28, pp.91-99.

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