Proceedings of the 5th International Conference on Environmental Science and Applications (ICESA 2024)
Lisbon, Portugal- November 18 - 20, 2024
Paper No. 156
DOI: 10.11159/icesa24.156

Automatic Identification of Aquatic Insects Based On Deep Learning and Computer Vision

Predrag Simović[1], Katarina Stojanović[2], Dimitrija Savić-Zdravković[3], Aleksandar Milosavljević[4], Milena Radenković[1], Ana Petrović[1], Bratislav Predić[4], Milenka Božanić[3], Djuradj Milošević[3]

[1]Department of Biology and Ecology, Faculty of Science, University of Kragujevac, Radoja Domanovića 12, 34000 Kragujevac, Serbia. predrag.simovic@pmf.kg.ac.rs; milena.radenkovic@pmf.kg.ac.rs; ana.petrovic@pmf.kg.ac.rs

[2]Department of Zoology, Faculty of Biology, University of Belgrade, Studentski trg 16, Belgrade, Serbia. k.bjelanovic@bio.bg.ac.rs; mika.zunic@bio.bg.ac.rs

[3]Department of Biology and Ecology, Faculty of Science and Mathematics, University of Niš, Višegradska 33 Niš, Serbia. dimitrija.savic@pmf.edu.rs; djuradj.milosevic@pmf.edu.rs

[4]Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14 Niš, Serbia aleksandar.milosavljevic@elfak.ni.ac.rs; bratislav.predic@elfak.ni.ac.rs

Extended Abstract

Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) (collectively referred to as EPT) represent an important component of assemblages of aquatic macroinvertebrates and often exhibit high diversity. Moreover, they are among the most effective indicators for assessing ecosystem health [1]. Current methods for freshwater ecosystem biomonitoring rely on the traditional approach of taxa monitoring based on morphological characteristics. This approach is time-consuming and often results in data sets with low taxonomic resolution and unverifiable identification precision. Therefore, one of the key challenges in biomonitoring programs is the ability to identify different taxa, ideally at a high taxonomic resolution (i.e., species level). To assist in solving identification problems, there was a need to develop alternative, reliable, and comprehensive approaches to macroinvertebrate sample identification.

Here, we establish an automatic, machine-based identification approach for EPT taxa (insects) using deep Convolutional Neural Networks (CNNs) and computer vision. This approach aims to increase efficiency and taxonomic resolution in biomonitoring. The 5,705 specimens were collected from freshwater ecosystems of Serbia, and the deep model was built upon 100 EPT taxa. The protocol for obtaining images included the following stages: taxonomic identification by human experts and DNA barcoding validation, mounting the larvae, and photographing the dorsal side using a stereomicroscope and camera (17,115 photos). The most informative image regions (the dorsal segments of individuals) for the decision-making process in the deep learning model were visualized using Gradient Weighted Class Activation Mapping (Grad-CAM) [2]. After training the artificial neural network, a CNN model was then built that was able to classify the 100 EPT taxa into their respective taxonomic categories automatically with 98.75%. Our model achieved a perfect classification rate of 100% for 79 of the taxa in our dataset. The Grad-CAMs generated indicate that the areas used by the model to recognize EPT taxa are similar to those used by entomologists. The head was the most important feature for classifying Ephemeroptera, while the thorax and abdomen were crucial for Plecoptera, and the head and thorax for classifying Trichoptera. Our approach offers a straightforward and efficient solution for routine monitoring programs, focusing on key biotic descriptors, such as EPT taxa. In addition, this application provides a streamlined solution that saves time, reduces equipment and expert requirements, and significantly enhances reliability and information content [3]. The identification of the EPT larvae is difficult because of the variation of morphological features even within a single genus or the close resemblance of several species, and therefore, future research should focus on increasing the number of entities (species) in the model. By automating species identification and monitoring, researchers can more efficiently track the health of aquatic ecosystems, enabling quicker responses to environmental changes. This research was conducted under the AIAQUAMI project number 7751676 funded by the Science Fund of the Republic of Serbia through the programme IDEJE_PN.

References

[1] V. Simić and S. Simić, "Use of the river macrozoobenthos of Serbia to formulate a biotic index,". Hydrobiologia vol. 416, pp. 51–64, 1999.

[2] R. R. Selvarju, M. Cogswell, R. Vedantam, D. Parikh, and D. Batra. L. "Grad-CAM: Visual explanations from deep networks via gradient-based localization," in *Proceedings of the IEEE International Conference on Computer Vision (ICCV)* 2017, pp. 618-626.

[3] E. Riabchenko, K. Meissner, I. Ahmad, A. Iosifidis, V. Tirronen, M. Gabbouj, S. Kiranyaz. J. P. "Learned vs. engineered features for fine-grained classification of aquatic macroinvertebrates," in *International Conference on Pattern Recognition (ICPR),* Cancun, Mexico, 2016, pp. 2276-2281.