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Exploiting prior knowledge for efficient Deep Learning: a case study about automated insect monitoring

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Pest insects threaten agriculture, reducing global crop yields by 40% annually and causing economic losses exceeding $70 billion, according to the FAO. Increasing pesticide use not only affects pest species but also beneficial ones. Consequently, precise insect population monitoring is essential to optimize pesticide application and ensure targeted interventions.
In today's AI-driven era, manual monitoring methods like sticky traps are being automated using image-based Deep Learning models. However, training these models requires large, typically unavailable species-specific datasets. Thus, leveraging prior knowledge from similar tasks is key for efficiently adapting to new invasive insects.
Our study focuses on training a Convolutional Neural Network (CNN) model, the EfficientNetv2. We compare training efficiency starting from two pretraining strategies: one using a pretraining based on the generic ImageNet dataset, and another employing an insect-focused version of the iNaturalist dataset. Moreover, we experiment with various training set sizes (1,000-30,000 images) and explore which EfficientNetV2 architecture sizes and layer-freezing strategies are most effective.
Results show that while EfficientNetV2-Large slightly outperforms Medium and Small variants, its longer training times are unjustified. Therefore, EfficientNetV2-Small is preferable. Furthermore, findings indicate that the optimal layer-freezing strategy depends on the pretraining type. Fine-tuning all layers performed best for ImageNet pretraining, while tuning only mid-to-final layers yielded higher performance than any ImageNet configuration when using iNaturalist pretraining.
We demonstrate that domain-specific knowledge combined with fine-tuning intermediate CNN layers offers an efficient learning strategy in case of limited data, enabling effective monitoring of insect populations and enhancing agricultural defenses against pest-induced yield losses.

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Primary author: MARTINEZ ESMERAL, Laura Carolina (KU Leuven)

Co-authors: Dr DE KETELAERE, Bart (Catholic University of Leuven); Prof. SAEYS, Wouter (KU Leuven)

Presenter: MARTINEZ ESMERAL, Laura Carolina (KU Leuven)

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