Automatic Insect Detection in Wildlife Videos

Dual-Branch Motion Detection and Tracking via Optical Flow, Background Subtraction, and Ensemble Classification

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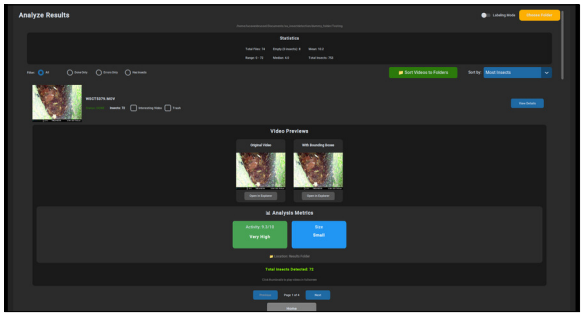
Introduction: The analysis of wildlife video recordings is an important task in forest entomology, yet manual inspection of video sequences is time-consuming and difficult to scale. This thesis presents an end-to-end pipeline for the automatic detection of insects in wildlife videos from natural microhabitats, such as water-filled tree holes, that were collected in the context of ecological research. These recordings are characterized by complex and changing background dynamics caused by illumination variations, environmental motion, and water surface effects.

Approach: To address these challenges, a dual-branch motion detection approach is employed, combining Gaussian Mixture Model (GMM) background subtraction and Optical Flow. The complementary strengths of both methods improve robustness against background motion and illumination variability. Detected motion regions are tracked over time and filtered using a Kalman-based tracking framework. The resulting object tracks are used to extract motion, shape and temporal features, which are then utilized for supervised classification. An ensemble classifier combining Random Forest and CatBoost is trained and evaluated on a custom, manually annotated dataset derived from the same wildlife video recordings. To support practical use in ecological research at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the pipeline is integrated into an easy-to-use graphical user interface, enabling non-technical users to process and analyze video recordings efficiently.

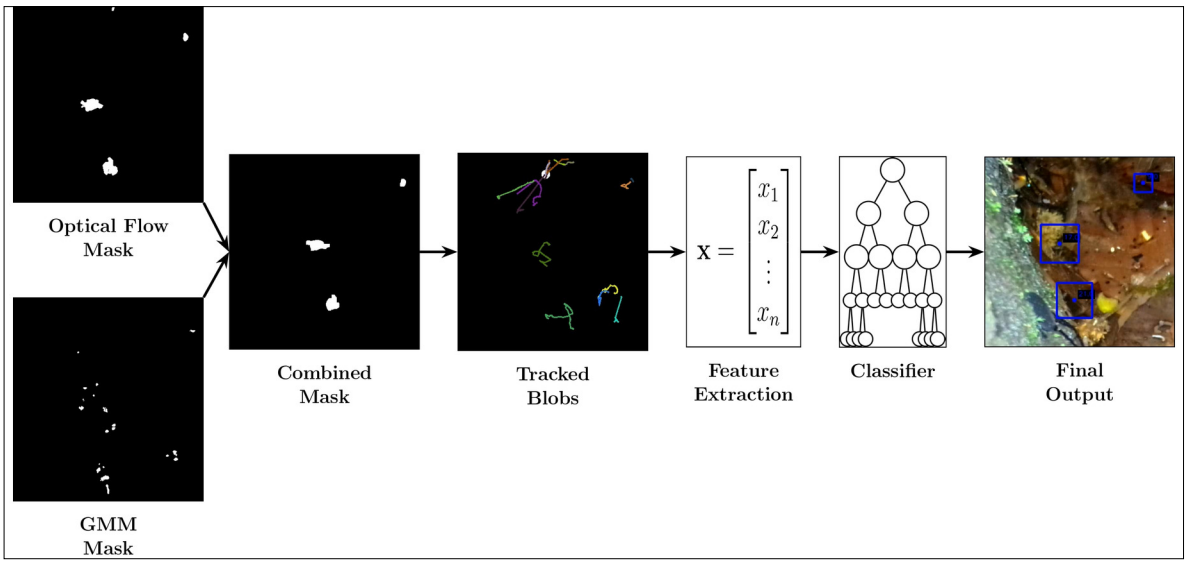
Result: The overall performance of the proposed end-to-end pipeline is assessed at system level, accounting for both classified detections and insects missed during the motion detection stage. On the test set, the pipeline achieves a system-level precision of 0.79, a recall of 0.80, and an F1-score of 0.80. These results indicate that the proposed pipeline provides a robust solution for the automatic detection of animals interacting with their surrounding microhabitats.

Classified output video
Own presentment

Analyzing-View of the Graphical User Interface
Own presentment



Overview of the complete pipeline
Own presentment



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Subject Area
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