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OmniTrax: A deep learning-driven multi-animal tracking and pose-estimation add-on for Blender

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Software

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Summary

`OmniTrax` is a deep learning-driven multi-animal tracking and pose-estimation Blender Add-on (Blender-Online-Community, 2022). `OmniTrax` provides an intuitive high-throughput tracking solution for large groups of freely moving subjects by leveraging recent advancements in deep-learning based detection (Bochkovskiy et al., 2020; Redmon & Farhadi, 2018) and computationally inexpensive buffer-and-recover tracking approaches. Combining automated tracking with the Blender-internal motion tracking pipeline allows to streamline the annotation and analysis process of large video files with hundreds of freely moving individuals. Additionally, `OmniTrax` integrates DeepLabCut-Live (Kane et al., 2020) to enable running markerless pose-estimation on arbitrary numbers of animals. We leverage the existing DeepLabCut Model Zoo (Mathis et al., 2018) as well as custom-trained detector and pose-estimator networks to facilitate large-scale behavioural studies of social animals.

Figure 1: OmniTrax user-interface.

Statement of need

Deep learning-based computer vision approaches promise to transform the landscape of large-scale human and other animal behavioural research. The goal of `OmniTrax` is to provide an interactive inference pipeline that decreases the entry barrier for researchers who wish to streamline annotation and analysis processes using deep learning-driven computer vision

tools. OmniTrax is designed to track and infer the pose of large numbers of freely moving animals. Unlike background subtraction, blob-detector, or optical-flow based approaches, common in multi-animal tracking (Kalafatic et al., 2001; Pérez-Escudero et al., 2014; Walter & Couzin, 2021), the use of deep learning-based detectors allows for buffer-and-recover tracking in changing environments. OmniTrax automatically initiates new tracks when an animal is detected for the first time and terminates the track when the animal leaves the recording site or becomes occluded for prolonged periods. OmniTrax uses a tuneable Kalman-Filter and the Hungarian Method (Kuhn, 1955) for cost assignment to extrapolate the 2D trajectories of identified animals across frames, so that temporarily missing detections, e.g. due to occlusion, motion blur, or other changes in appearance, can be compensated.

A key advantage of integrating such a pipeline into Blender is the seamless transition between automated tracking and iterative user-refinement. Additionally, Blender offers a number of video editing and compositing functions which make it possible to perform pre-processing of the imported video footage. This includes cropping, masking, or exposure adjustment, prior to running inference within the same environment, without relying on external software packages.

OmniTrax additionally offers markerless pose-estimation through DeepLabCut-Live (Kane et al., 2020) which enables extracting kinematic parameters from virtually arbitrarily large groups of individuals. We are using OmniTrax in ongoing research monitoring foraging activities of various species of leafcutter ants, tracking the movements of thousands of individuals to extract path choice and changes to gait patterns.

Through a library of neural networks trained on hand-annotated as well as synthetically generated samples of a number of digitised study organisms (Plum et al., 2023; Plum & Labonte, 2021), we provide a range of out-of-the-box inference solutions and encourage the community to contribute to this emerging collection. Pre-trained detection and pose-estimation networks can be used within OmniTrax to accelerate the annotation and analysis process of large video data sets. The ease of use and focus on extendibility of OmniTrax will aid researchers in performing complex behavioural studies of social animals under laboratory as well as challenging field conditions.

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