The Journal of Open Source Software

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

Fabian Plum [1]

1 Imperial College London, Department of Bioengineering, United Kingdom

DOI: 10.xxxxxx/draft

Software

- Review
- Repository
- Archive

Editor: Kevin M. Moerman

Reviewers:

- @lucasmiranda42
- @jonmatthis

Submitted: 23 April 2023
Published: unpublished

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 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.

The Journal of Open Source Software

`OmniTrax` is designed to track and infer the pose of large numbers of freely moving animals. Unlike background subtraction and blob-detector based approaches, common in multi-animal tracking, the use of deep neural networks allows for buffer-and-recover tracking in changing environments. 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 any required pre-processing. This includes cropping, masking, or exposure adjustment, prior to running inference on video footage within the same environment, without relying on external software packages.

`OmniTrax` 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.

Acknowledgements

This study was funded by the Imperial College's President's PhD Scholarship (to Fabian Plum) and is part of a project that has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement No. 851705, to David Labonte). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

Blender-Online-Community. (2022). *Blender - a 3D modelling and rendering package*. Blender Foundation. http://www.blender.org

Bochkovskiy, A., Wang, C.-Y., & Liao, H.-Y. M. (2020). *YOLOv4: Optimal speed and accuracy of object detection*. https://doi.org/10.48550/ARXIV.2004.10934

Kane, G., Lopes, G., Sanders, J., Mathis, A., & Mathis, M. (2020). Real-time, low-latency closed-loop feedback using markerless posture tracking. *eLife*. https://doi.org/10.7554/eLife.61909

Mathis, A., Mamidanna, P., Cury, K. M., Abe, T., Murthy, V. N., Mathis, M. W., & Bethge, M. (2018). DeepLabCut: Markerless pose estimation of user-defined body parts with deep learning. *Nature Neuroscience*. https://doi.org/10.1038/s41593-018-0209-y

Plum, F., Bulla, R., Beck, H. K., Imirzian, N., & Labonte, D. (2023). replicAnt: A pipeline for generating annotated images of animals in complex environments using unreal engine. *Nature Communications*, *14*. https://doi.org/10.1038/s41467-023-42898-9

Plum, F., & Labonte, D. (2021). scAnt — an open-source platform for the creation of 3D models of arthropods (and other small objects). *PeerJ*, *9*, e11155. https://doi.org/10.7717/peerj.11155

Redmon, J., & Farhadi, A. (2018). YOLOv3: An incremental improvement. *CoRR*, *abs/1804.02767*. http://arxiv.org/abs/1804.02767