18-Sep-2022

MEE-22-06-507 Towards individual-based pollination ecology: Automatic tracking of life histories of individual flowers

Dear Mr Hjalte Mann,

Thank you for submitting your manuscript to Methods in Ecology and Evolution.

A member of our Associate Editor Board and I have now read your manuscript in detail. Unfortunately, based on this reading and the comments I have received from the Associate Editor (which can be found below), it was my opinion that your paper would be unlikely to make it through the review process at Methods in Ecology and Evolution in its current form.

In light of these concerns, I must decline your manuscript for publication in Methods in Ecology and Evolution at this time. However, we would be willing to consider a new manuscript that takes into consideration the comments you have received. In addition to these comments, I also have some comments of my own that should be addressed:

1-please follow the guidelines for code and especially code testing detailed in the instructions to authors on MEE's webpage; although these were tailored for application papers, your work relies a lot on coding and make it stable over the long-term is essential;

Response

~~2-please add a figure (which can become the first of the paper) synthetizing the does and don't + the logic behind individua-based pollination ecology and how automatic tracking add a piece to the puzzle. This will not only help users see the value and the steps of your approach but put it in a wider context. These types of figures are usually good features of our papers and attract a wide range of ecologists to try new methods;~~

Response

We have added a figure (fig. 1) that visualizes the input and output of individual flower tracking to help the reader understand the suggested method and its value.

3-Add a larger context in the discussion about automation and how this help solve some of the actual and future shortcomings of pollination ecology and life-history tracking + how to do you see your method blossom in the near future and how it can be even more expanded.

Response

We have adapted and expanded the discussion to put the concept of automated ecological data collection and our particular method in a wider context.

Please read the resubmission instructions at the end of this email before submitting your updated manuscript. The deadline for your resubmission is 17-Dec-2022. As well, please note that Methods in Ecology and Evolution is becoming a fully Open Access journal. All new papers, including resubmissions, submitted to the journal from 6 July 2022 will be open access on publication. For more information on how this may affect you, please go to our OA information page here: <https://besjournals.onlinelibrary.wiley.com/hub/journal/2041210X/about/open-access>

This is a simple and logical algorithm to track individual features which move between successive pictures. This tracking goes beyond the tracking of immobile features, such as plants. In this sense, your algorithm is a novel feature which could be of interest to ecologists in general.

Response

We agree that tracking based on displacement of objects between frames is a generic method relevant for many object types.

The reviewers and I have have found several ways to improve this work.

I share reviewer 1's main concern that it is unclear how well your algorithm works in a general setting – for example, in communities with taller vegetation where the chance of overlap among flowers is higher. This is an important concern: if this algorithm is to reach as many people as possible, it is necessary to understand for what type of vegetation it a useful tool. How much work is needed to adapt this algorithm to other datasets? This is a relevant question, because you only have data for two, similar species (both from the genus Dryas). Do you have other datasets to address this concern? If not, would it make sense address this using simulation (e.g. looking at how the three parameters of the algorithm can accommodate specific issues in datasets)? If not, why is this dataset an example of general relevance? You also indicate your algorithm needs be adapted to different datasets.

Response

Tracking based on displacement between centroids of objects is a generic approach which has been implemented for objects other than flowers. The approach benefits from its simplicity and is easy to test on other data. The user-adjusted parameters added to the algorithm was designed with flower tracking in mind but can be relevant for other object types. To present the algorithm and the associated parameters in a more general way, we have now included examples based on simulated data. The examples visualize the use of each parameter as well as the importance of frame rate versus movement for reliable tracking. High frame rate/low movement eases the task of associating instances of an object between frames. On the other hand, Low frame rate/high movement makes this task difficult.

The code and data for this added section is also made available for the reader.

Reviewer 1 also urges you not conflate the concept of individual flower phenologies with individual plant phenologies (e.g. L 80-86, 95-104, 425-426). This is a subtle, but important point.

Response

We have edited the text at the specified lines to make it explicit that we are talking about individual flower phenology.

Reviewer 2 suggests emphasizing the indirect applications of this algorithm – please see attached PDF for details.

Response

We have taken the comments in the PDF into account and implemented changes accordingly where relevant.

Somewhat related to the main concern of reviewer 1, you should justify the use of this algorithm with respect to other options. Could this tracking be accomplished, in principle, using machine learning or AI? If yes, why is this algorithm advantageous/necessary?

Response

As described in the introduction, solutions exist that use deep learning methods to augment object tracking, for example by recognition of an object between frames. However, the low variation in appearance between individual flowers means that this is not a reliable approach for flower tracking. We are not aware of any methodology for object tracking fundamentally based in deep learning nor how this would be achieved. The benefit of the presented method is its simplicity, which means that it is readily testable on other data, without e.g. training of neural networks. For specific use-cases – e.g. tracking easily distinguishable objects, other and more advanced methods may be preferable. In the present paper, we make the point that it is feasible to track individual flowers in image time-lapse series, opening up new possibilities for studies of flower ecology.

What is the relationship between this article, and Mann et al. 2022? You cite Mann et al. 2022 only once in the article. How is this work related to this, and how do they complement each other? I only skimmed Mann et al. 2022, but I understand that that article uses flower detection, rather than flower tracking. If so, state it clearly. Also, state that Mann et al. 2022 would be a first step in a pipeline that 1) identifies flowers in every picture, 2) tracks these flowers (IF and only IF, this is correct; this is what I have understood). Emphasizing difference between Mann et al. 2022 and the present manuscript is also relevant in the introduction, where your emphasis on "tracking" versus image detection should be much more clear (lines 87-104). In the current manuscript, I expect that readers will get confused between these two topics. Your algorithm "tracks" individual flowers, rather than simply identifying them. While this is relatively straightforward in plants whose base is fixed, flowers can move quite a bit through their petioles (Interestingly, an algorithm to track plant individuals has been just published in Methods in Ecology and Evolution; Stears et al. 2022).

Response

We have made clarifications in the introduction as well as the discussion.

In the methods, I feel it would be helpful to immediately provide an overview of the most common tracking errors. In line 198 you talk about “a tracking error known as fragmentation”. It would be nice to have an overview of all the most important tracking errors, in order to set up the language for the two tracking errors you present in Figure 4.

Response

We have added a description of relevant tracking errors. Further, we have restructured the section so that the paragraph *Common tracking errors and evaluating tracking performance* includes both an overview of the tracking errors as well as the description on how to measure tracking performance.

Finally, in the section "Identifying the most reliably tracked flowers" (line 311): this section and its link in the introduction should be clarified. In line 312, you need to explain once again that some flowers cannot be reliably tracked by the algorithm, but that some flowers will be tracked almost perfectly. This filtering is needed to identify the flowers that can be tracked with certainty or near-certainty. Regarding the above, you explain this part of your analysis in lines 132-138: however, this section should go right after "We describe three user-defined parameters to help optimize tracking of flowers in particular", to clearly emphasize the limitations of the algorithm.

Response

We have made the suggested improvements to the introduction and the methods section.

MINOR COMMENTS

71 Remove "B. D." from this citation, and all subsequent citations.

111: "violate" rather than "violates"

294-298: The sentence is too long; please split this up in at least two sentences. Also, the sentence is unclear: if you mean that you have no false positives/negatives, because you do not work on CNN data, then state it.

317: "two points. we": remove the dot.

321: what do you mean by "collinear" points?

384-385: Should be "The y-axis shows the track IDs". Talking about the "correct" track ID, would imply a legend for the different color (which will presumably refer to correct and incorrect track ID).

571-586: Discussion section on pollination has not been tested. It is therefore mostly speculative.

Figure 3: Please plot the jittered data points over the boxplots. This is good practice by allowing to see raw data points.

723 The formatting of the DOI link is incorrect

Improvements and corrections made for all points.

REFERENCES

Stears, A. E., Adler, P. B., Albeke, S. E., Atkins, D. H., Studyvin, J., & Laughlin, D. C. (2022). plantTracker: An R package to translate maps of plant occurrence into demographic data. Methods in Ecology and Evolution. <https://doi.org/10.1111/2041-210X.13950>

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