Response for PCIEcology [Peer Community In Ecology]

Dear Editor,

Thank you for your review of our entitled "Rapid literature mapping on the recent use of machine learning for wildlife imagery" (**https://doi.org/10.32942/X2H59D** version 3 *Submitted by Shinichi Nakagawa 31 Oct 2022 22:05*).

We believe that we have addressed all of the comments of the editor and peer-reviewers and that the article is now considerably stronger.

Below, we append our response with:
The reviewer comment number and the comment;
The page number of edit (in the new draft) and a description of our edits

As requested, the changes to manuscript were done as tracked changes.

We now added links to the data and code deposited on Zenodo at https://doi.org/10.5281/zenodo.7502948 and referenced accordingly in the manuscript. We have updated our "Data and Code Availability", "Supplementary Information" "Funding" and "Conflict of Interest" sections, as recommended.

Please contact me if I can be of any further assistance.
Sincerely,

Comments and our replies (in green)

Round #1

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by Olivier Gimenez, 19 Dec 2022 12:12
Manuscript: **https://doi.org/10.32942/X2H59D** version 3

Decision on "Rapid literature mapping on the recent use of machine learning for wildlife imagery"

Dear Dr Nakagawa,

We have now received 2 reports on your preprint written by experts in the field.

I would like to apologise for the tone used by Dr Falk Huettmann which I find aggressive and inappropriate (I might read it wrong, English is not my first language).

Now trying to read between the lines of his report, I guess there is a convergence with the second major issue raised by the other referee, in that the study should be

better motivated, the results explored in the light of the existing reviews on ML/AI and the main messages explicitely pitched.

The first major issue raised by the anonymous referee shouldn't be too difficult to address.

I realise that revising your manuscript will require extensive work, but I recommend a revision instead of a rejection cause I'd like to read another version of your work.

Cheers,

Olivier Gimenez

REPLY 1

We are grateful for the opportunity to revise our manuscript. We believe we have now addressed the main concerns regarding flashing out the study motivation, main messages, and relevance to the existing reviews on this topic, as specified in our detailed responses to Reviewers below.

Reviews

Reviewed by anonymous reviewer, 29 Nov 2022 15:18

I had the pleasure to read the manuscript by Nakagawa et al which proposes an overview of the use of machine learning algorithms for wildlife imagery. The manuscript is based on an automatic literature survey and intend to answer different questions about the trends in this filed (ML for wildlife image). The paper is interesting and the different steps are well described. Still, the quality of the english writing could be greatly improved (the english is correct but could be more fluid).

REPLY 2

Thank you for the positive feedback, The manuscript has been read and improved by native English speakers.

However, I have a number of concerns, actually two major issues that I would like to share with the authors, hoping this could help improving the manuscript.

First, the authors explain that this is a "rapid" review ("rapid" is actually used in the title as well). Whereas I understand that it is important to be fast when studying a very active field, I am not really convinced that "rapid" does not imply "incomplete" study. Could the authors tell us what would have been a "not rapid" review, and explain how much it would have been too long to perform?

REPLY 3

We can understand that not all the reader would be familiar with the concept of Rapid review. To explain how they differ from fully comprehensive Systematic Review, we now added the following sentences in the Introduction: "Notably, a fully comprehensive Systematic Review takes on average 2 years (Tricco et al, 2015; Morah et al., 2017)and a Rapid Review can be completed in a few months (Schünemann et al., 2015; Haby et al., 2016) , providing more timely, and usually unbiased, snapshot of the research knowledge (Ganann et al., 2010; Affengruber et al., 2020)." (new lines 78-81)

Also see the wiki page - https://en.wikipedia.org/wiki/Rapid_reviews

In the manuscript, I was alerted to the quality/exhaustivity of the results when observing that 1/ many figures show decreasing (and misleading) trends for year 2021 compared to the others; 2/ many species were not checked by the authors when collecting the species involved in re-id studies. 1/ On every figures showing paper counts, there is a decreasing slope for 2021. The reader can consider this slope as a trend, whereas this is only because papers after October 2021 were not used. I don't think this is reasonnable to truncate 2021 whereas the data are now available.

REPLY 4

We now extended our literature search to cover the whole of year 2021. We have included extracted 30 additional publications and updated all the code, figures, and results accordingly.

2/ It appears that the authors missed a number of papers with their SCOPUS request, at least for species re-id. Species list for re-identification in Figure 1D does not account for birds (Ferreira et al, MEE 2020), giraffe (Buehler et al Eco Info 2019; Miele et al, MEE 2021), elephant (Körschens et al), ray manta (Moskvya et al) nor fruit flies and octopus (Schnieder et al, IEEE 2019). As a consequence, I am still a bit confused about how much the presented results are exhaustive.

REPLY 5

We thank the reviewer for suggesting additional, potentially missing, articles for our literature survey. Our original dataset already included one of the suggested studies (Ferreira et al, MEE 2020). Another one (Schnieder et al., 2019) is not eligible, because it is on invertebrates and our inclusion criteria only allows studies on vertebrates. We have added the remaining three suggested studies (Buehler et al 2019; Miele et al. 2021; Körschens et al. 2019) to our updated dataset and results. We would also like to clarify that rapid review is not meant to be exhaustive by definition. If it was, it would be a full systematic map and it would involve searching multiple databases and other literature sources. It would also take prohibitively long time. However, we have used a broad-coverage literature database with a pre-piloted and benchmarked search string, so we have likely sampled literature across

Second, I really appreciated the explanations all along the paper about the different questions and the different way of answering these questions. Meanwhile, I would recommend a better presentation of the take-home messages. The paper remains very descriptive (which is great) but it is hard to get the actual messages raised by the analysis -unless I missed something, which is quite possible. Yes, there are many studies using camera traps, deep learning, with people from countries outside of the study site. But how much these results show expected or new trends, how much they inform the reader, how much they complement the reading of nice review papers such as Besson et al, Eco Lett 2022, Tula et al, Nature Comm. 2022, Christin et al, MEE 2019.

I also have a list of minor points:

- Code sharing is now a prerequisite for many journals. I would have been interested in observing the temporal trend in the percentage of papers with shared code, and possibly by journal (I think fo instance it is mandatory for MEE). Indeed, the present manuscript could highlight an interesting message about how much code sharing practices are adopted by the community.

This is a great suggestion. We now added additional supplementary figures exploring temporal trends, journal and discipline-related patterns(Figure S10 and S12). We refer to this information in the main text as follows: "' (new lines)

- Another missing point is the scientific domain of the authors: how frequent are multi-disciplinary teams, involving which disciplines ?

 REPLY 8

It is a very interesting idea. We would love to add such analyses, however, assigning disciplines to individual authors is prohibitive for a few reasons. The main reason is that such information is not explicitly and systematically included in the bibliographic records used for analyses. Retrieving this information from affiliations is not always possible, e.g., if only university name is provided. Alternatively, lists of publications by a given author could be classified by discipline using data from other databases (e.g., journal subject area classification by Scimago), but the authors' names are often not unique (and affiliations can change over time), so they and cannot be reliably linked to their other publications. We are not aware of workable solutions to these author identification and classification problems, and thus cannot assess which of the author teams are multi-disciplinary.

l22: missing coma after "count"

REPLY 9

Fixed, thank you (new line 22)

l23: a lack in survey? well, there are nice review papers Besson et al, Eco Lett 2022 , Tula et al, Nature Comm. 2022, Christin et al, MEE 2019

REPLY 10

We wrote our manuscript at the start of year 2022 when the nice review by Besson et al, Eco Lett 2022 was not available yet. We do cite Tuia et al, Nature Comm. 2022 in our manuscript. These two reviews are not systematic reviews/maps or other systematic surveys of literature. The review by Christin et al. (MEE 2019) is also mostly a narrative review with a very brief and poorly documented systematic literature survey encompassing only literature up to 2019. We now rephrased the abstract as following: "Yet, we currently have a very few systematic literature surveys on its use in wildlife imagery." (new lines 23-24). We also write in the Introduction: "Yet, there is no systematic survey of this emerging and important field (cf. Caravaggi et al., 2017; a review by Christin, Hervet & Lecomte, 2019 is mostly narrative, and includes a brief survey in one of its sections)." (new lines 71-73)

I.29 CONVOLUTIONNAL neural networks

REPLY 11

Added, thank you (new line 30).

l:.29-30 unclear

REPLY 12

We agree with the reviewer. We now rewrote the whole paragraph, as follows: "We found that increasing number of studies used convolutional neural networks (i.e., deep learning). Typically, studies have focused on large charismatic or iconic mammalian species . Increasing number of studies is published in ecology-specific journals indicating the uptake of deep learning to transform detection, classification and tracking of wildlife. Sharing of code was limited, with only 20% of studies providing links to analysis code." (new lines 29-35)

l.53 10 years into one week? it seems overestimated

REPLY 13

According to the cited paper (Norouzzadeh et al., 2018): "With 50k images (138.9 h), 91.4% of the entire pipeline can be automated." and this number for their full data set (1,514,000 images, as in the SI, Table S.$) goes up to 98.8%. The authors earlier say that their pipeline is "saving >8.4 y (i.e., >17,000 h at 40 h/wk) of human labelling effort on this 3.2 million-image dataset", which we rounded to 10 years. The authors assume the automating labelling takes "a conservative 10 s per image", which for the whole data set would mean approximately 8889 hours (370 days or 12 months). The calculations are rough, and we probably underestimated how long the project of that size would take, even with automatic labelling, especially given that some images would still need to be cross-checked manually. We now adjusted the numbers accordingly: "For example, a well-trained deep learning model can process video recordings and camera trap data extremely efficiently, reducing ten years of manual human work to around one year by automating up to 99% of the entire (Norouzzadeh et al., 2018)." (new lines 56-58)

l.54-64 paragraph with some redundancy

REPLY 14

Thank you for noting this we now revised the paragraph to make it more concise: "This rapid and efficient processing opens possibilities for obtaining critical and detailed information on species' ecology, demography, life history and behaviour at previously impossible temporal and spatial scales (Villa, Salazar & Vargas, 2017; Christin, Hervet & Lecomte, 2019; Lamba et al., 2019; Tuia et al., 2022). This is increasingly useful for both in-situ and ex-situ conservation. Unsurprisingly, conservation biologists and wildlife biologists are progressively employing machine (deep) learning algorithms to process image data, often collaborating with computer scientists (e.g., Tabak et al., 2019; Willi et al., 2019). Review articles are also appearing on applications of machine (deep) learning can support ecological research and conservation (e.g., Christin, Hervet & Lecomte, 2019; Lamba et al., 2019; Nazir & Kaleem, 2021)." (new lines 58-69)

74. The use of "rapid" is pejorative

REPLY 15

We changed it to "Rapid Review", which is an accepted name for this type of approach to reviewing evidence, without negative connotations. (new line 79).

l.78 'research weaving'? what's the interest of rapid approach then ?

REPLY 16

We combine these two approaches, because they are complementary to each other. We use rapid review to weed out studies that were captured by the literature search, but are not relevant to the review topic. We than collect information by manually coding study focus and methods, and by using information from related bibliographic records. We clarify this as follows: "In this work, we also use a 'research weaving' approach to incorporate bibliometric information in a systematic-like map of the empirical studies (Nakagawa et al., 2019). First, we manually map the content of recent studies (published between 2017 and 2021) that were utilising machine learning to process wildlife imagery." (new lines 89-91)

l.88 "analysis code" => "source code to reproduce the analysis"

REPLY 17

We incorporated this suggestion (new line 100).

l.104 typo "it can be" instead of "I can be"

REPLY 18

Fixed, thank you.

l.105-107 should me moved to introduction.
Alternatively 100-107 could be moved as a whole to the intro

REPLY 19

We moved this sentence to the end of the introduction, as suggested (new lines 111-113)

l.116 two commas + why lower case then upper case?

REPLY 20

Thank you for noting this, we have removed two commas, which were a typo. We adjusted the case of the other terms in this sentence. (new lines 130-131)

l.118 do we say "thermal imaging" ?

REPLY 21

Yes, this term is used in the field, e.g. Still, Christopher, et al. "Thermal Imaging in Plant and Ecosystem Ecology: Applications and Challenges." Ecosphere (Washington, D.C), vol. 10, no. 6, 2019, p. n/a. doi: 10.1002/ecs2.2768.

l.123 what is, for the authors, the difference between "recognition" and "classification" ?
Actually the sentence with multiple entry using "/" is not correct
(what would be "individual animal classification" ?)

REPLY 22

We acknowledge that this short sentence tries to include many different options, reflecting diversity of the existing studies in this domain. Some studies just look at images with and aim of identifying a shape of a given (or any) animal and driving a bounding box around it for further processing (or issuing an alert message) – those are animal/species "recognition" studies. Other studies would follow this step with and additional step of classifying what animal/species is in a box – those are "classification" studies, and they include individual re-identification studies, i.e. "individual animal classification". To clarify, we now added the following: "We recognised six main outcome types: "species recognition/classification (object detection)", "individual recognition (re-identification)", "counting individuals (at given time)", "tracking (following through space)", "behaviour detection (at given time)", "behaviour classification (changes over time)")." (new lines 139-142)

l.233 "The primary use of machine learning ... followed by individual recognition (19% of studies)" what is this 19% ? I don't think only 19% of studies used machine learning.

REPLY 23

We rewrote this text fragment as follows: "Object recognition / classification, which involved object detection in the image, was the first and essential step mentioned in almost all (94%) included studies. Additional steps of image processing included individual recognition (re-identification), counting individuals (at given time), tracking (following through space), behaviour detection (at given time), behaviour classification (changes over time). Individual recognition and re-identification were an objective of 20% of studies." (new lines 257-262)

l.239 Sentence not clear.

REPLY 24

We rewrote the paragraph and the sentence in question: "Unsurprisingly, neural networks were used in the context of all types of image processing outcomes (Fig. 3 A)." (new lines 266-268)

l.309 Is this paper using GBIF relevant for the present bibliographic study? not convinced.

REPLY 25

We apologise for the confusion here. The GBIF database is not limited to species occurrence data, it also includes 1.2 million photos of nearly 20 thousand species, which were used in the aforementioned study. As such the study is relevant. To clarify this we modified the sentence as follows: "The paper with 16,583 species included an exceptionally wide range of species, because it tapped into 1.2 million of images available on GBIF (the Global Biodiversity Information Facility; Mo, Frank & Vetrova, 2017)." (new lines 335-336)

Figure 3: how could the algorithm be "unclear" ?

REPLY 26

The algorithm itself cannot be "unclear", but the description of it can. We now clarify this in the figure legend as follows: "Algorithm types that were outside the main six categories or were described to vaguely to be classified were coded as "other / unclear". (new lines 246-248)

Reviewed by Falk Huettmann, 11 Dec 2022 10:41

Hello,

thanks for the manuscript (MS) titled 'Rapid literature mapping on the recent use of machine learning for
wildlife imagery' by Nakagawa et al.

I found this work not much relevant or informative, hardly needed.

I have a hard time with the title, "mapping"! as I see no map and just a description of a fast and rapid online search. Already a research design is widely absent, no valid hypothesis formed or tested.

REPLY 27

We emphasize with the reviewer on this issue. However, the purpose of this type of research is not to test a hypothesis but to describe the pattern, in this case a status-quo and trends in the use of machine learning algorithms in wildlife research. The research design is encompassed in the literature survey design, which is described in detail and fully transparent. Our main approach to collecting relevant literature was a systematic-like review, termed Rapid Review. Rapid Reviews are an established research method in many disciplines, especially in medicine. We clarify this in the Introduction section, as follow: "We use a "'Rapid Review" approach, which abbreviates the process of systematic maps by not being comprehensive but being representative (Lagisz et al., 2022)." (new lines 79-80)

Instead of 'rapid' I propose we can have a THOROUGH and DEEP REVIEW of the topic; that would be better. Why here quick and dirty, and how justified ?

REPLY 28

We now provide an expanded justification in the Introduction: "A fully comprehensive systematic review takes on average 2 years (Tricco et al, 2015 ; Morah et al., 2017)and a rapid review can be completed in a few months (Schünemann et al., 2015 ; Haby et al., 2016), providing more timely, and usually unbiased snapshot of the research knowledge (Ganann et al., 2010; Affengruber et al., 2020). Importantly, in this work we also use a 'research weaving' approach to incorporate bibliometric information in a systematic-like map of the empirical studies (Nakagawa et al., 2019), to provide deeper insights on the topic." (new lines 83-89)

While the MS is well written, it has virtually nothing in there that is not known, or relevant for conservation. It's an incomplete book-keeping effort for the year 2022; how is that science or helps wildlife management and sustainability ?.

REPLY 29

We appreciate the reviewer's concern. The role of systematic maps is to direct the readers and practitioners to most relevant literature. For example, using our data set, one can easily locate 10 studies on individual re-identification of tigers or the only such study done on salmon species. The dataset allows pulling out the studies that provided the links to their analysis code if one would like to re-use code for their own project. Overall, the benefits is in identifying subsets of studies by types of images, outcome or algorithm type. Even if our literature search was not fully exhaustive, it is based on pre-piloted and sensitive (at around 90%) search strategy, likely identifying majority of the relevant studies in this domain and indicating where research gaps are. We now emphasize this in the Discussion section: "However, this study provides some current insights, providing new perspectives, revealing gaps and gluts of current work and areas for improvement, especially in terms of reporting practices." (new lines 447-449)

The biggest science budgets are in the U.S. (by far), and per capita, in Canada, and later EU. So what's new ? Any science effort - including camera trap data work, relfects nothing but that.

REPLY 30

We provide specific insights and recommendations in our Discussion section as follows: "Such incongruence could be related to scientific colonialism, initiating discussions on the ways to decolonise science (Baker, Eichhorn & Griffiths, 2019; Trisos, Auerbach & Katti, 2021). Building capacity and involving local collaborators including indigenous peoples could be a first step towards resolving this incongruence, increasing representation of underrepresented nations and their wildlife imagery. There is also considerable scope for more international collaborations, given only three studies had authors from multiple countries." (new lines 390-396).

When it comes to 'wildlife', why not using biodiversity and endemic species ? That would be more insightful.

REPLY 31

We are not sure what the reviewer refers to here. Many of the wildlife species identified as subject of machine learning studies, are endemic and all are part of biodiversity.

Then, as a key issue, conservation: How about these days we publish wildlife species to death in books, and with ML/AI and camera traps (tons of data), while the actual species, habitats and wilderness are vastly on the decline. So what is really the progress ? Already the CO2 footprint of science, camera traps, imagery, ML/AI and gear is a conservation 'sink' due to the consumption. It's niot sustainable whatsoever.

REPLY 32

We share the reviewer's concern about the state of the natural environment. We assure the reviewer that apart from publishing manuscripts we do engage with real-life conservation work and advocacy which benefit the natural environment.

That's the reality picture, but authors totally are silent - neoliberal- about it. Adding viepoints from Ecological Economics would help here and are expected.The topic of POVERTY is widely ignored, but a key issue worldwide, and for wildlife. One may add the 8 billion people, climate change etc. Myself, I am always concerned when 'spying' is not discussed in such data, e.g. camera traps, drones, planes.

REPLY 33

We acknowledge that the topics of poverty and spying are outside our expertise and the scope of the manuscript. They are also not discussed in the publications included in the dataset.

Lastly, I totally agree on the topic of no data sharing in such applications. That's indeed a great topic of failure but widely known and just a marginal result in the MS; see (missing) camera trap data in Antarctica, Svalbard or in GBIF by mandated member nations, and then, see NGOs often being excempt. And include metadata in this dicussion.

REPLY 34

We agree on the point on the importance of data and code sharing. Although we did not explicitly evaluate data and meta-data availability, we noted that many of the included studies used freely available datasets (e.g., from Kaggle). Such datasets allow researchers from any country to develop and test machine learning approaches (given they have access to the Internet and other computational resources, which is still a concerning issue in many developing countries). The data from some specific project collecting camera trap images may be subject to proprietary laws (or safety concerns in relation to some critically endangered species) and not shared openly. We hope this will change in the future. Regarding code sharing, we make the following recommendations in our manuscript: "We recommend that the code and relevant data be made available according to the

FAIR principles (findable, accessible, interoperable & reusable; Wilkinson et al., 2019)." (new lines 419-420).

Anyways, how does all of this serve mankind, or wildlife better ?

REPLY 35

We hope our work will help researchers attempting to use machine learning in wildlife research by identifying what has been already done, how, where and by whom. This way, they can follow the best practice, most successful approaches, and focus on filling in the gaps in our knowledge, hopefully with the benefits to the mankind and wildlife. We now emphasize this in the Discussion section: "However, this study provides some current insights, providing new perspectives, revealing gaps and gluts of current work and areas for improvement, especially in terms of reporting practices." (new lines 447-449)

I see nothing relevant or new provided in this MS, just another endless re-chew of things most people know with some R-type graphs (but data are 'rapid' and thus not thorough). May we call this internet research ?

REPLY 36

The research on research is actually called meta-research. It allows to identify strengths and weaknesses in existing research, fostering better and more efficient science by identifying gaps and biases.

Overall, I find this MS not so informative and poorly thought out. It oversells itself.

Thanks, that's my assessment of this worlk.

Kind regards

   Falk Huettmann

REPLY 37

Thank you for your time on this review. We appreciate diversity of perspectives.