Artificial Intelligence in Ecology and Evolution : potential and limits

E2M2 webinar

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26/06/25

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AMAPlab
E2M2 EVOLUTION ECOSYSTEMES MICROBIOLOGIE MODELISATION
ÉCOLE DOCTORALE

Outline

1. Why use deep learning in ecology ?

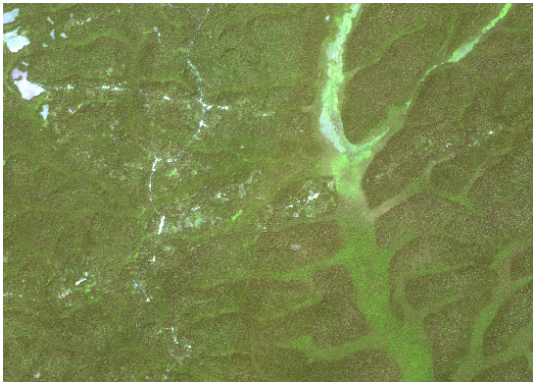
2. What are the cases where deep learning does work ?
   and other models don't

3. What are the cases where deep learning doesn't work ?
   Common traps when working with living things

4. How will it evolve ?

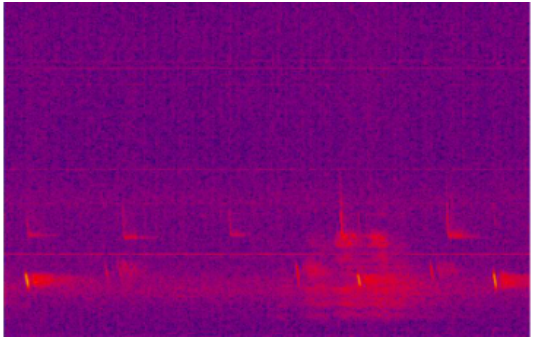
Why use deep learning in ecology ?

More and more data



- UAVs, Satellite

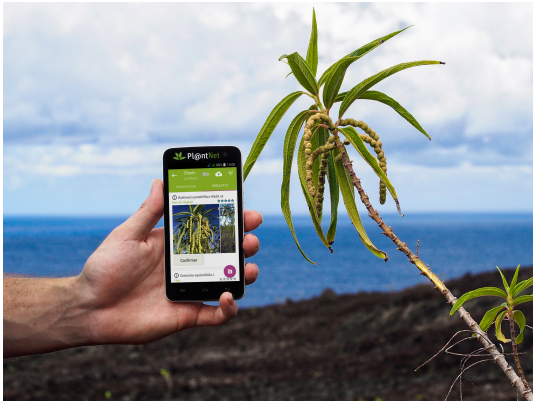
More and more data



- UAVs, Satellite
- Camera trap, accoustic

Mac Aodha *et al.* 2022

More and more data



- UAVs, Satellite
- Camera trap, accoustic
- Citizen science

plantnet.org

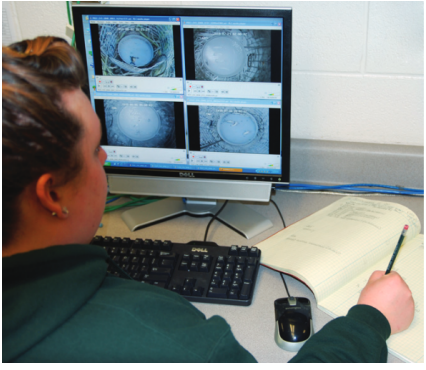
More and more data

- UAVs, Satellite
- Camera trap, accoustic
- Citizen science

➔ **Better coverage, better monitoring**

Data analysis and interpretation is time consuming

- A computer does not sleep
- A computer does not get tired



Grieshop *et al.* 2012

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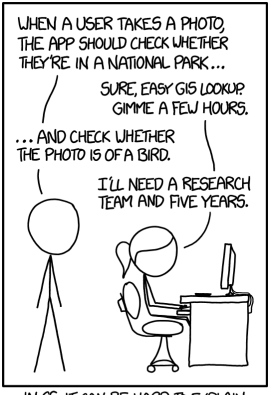
➔ **Automation now possible**

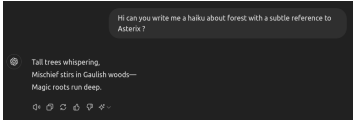


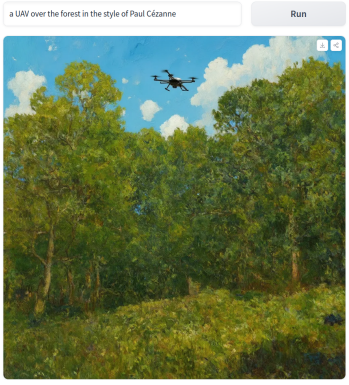
xkcd 1425, 2014

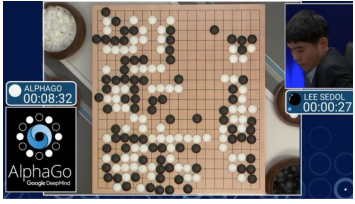
What are the cases where deep learning does work ?

and other models don't

Model complex, non-linear and abstract relationships







Interpolation and generalisation

Unonopsis stipitata Diels

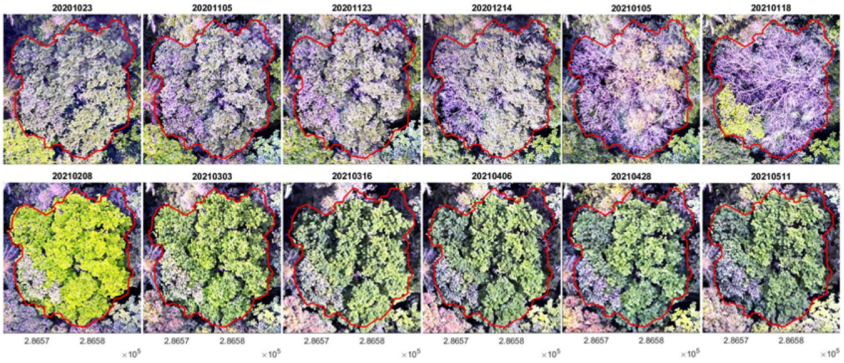
PlantClef 2020 Dataset

What are the cases where deep learning doesn't work ?

Common traps when working with living things

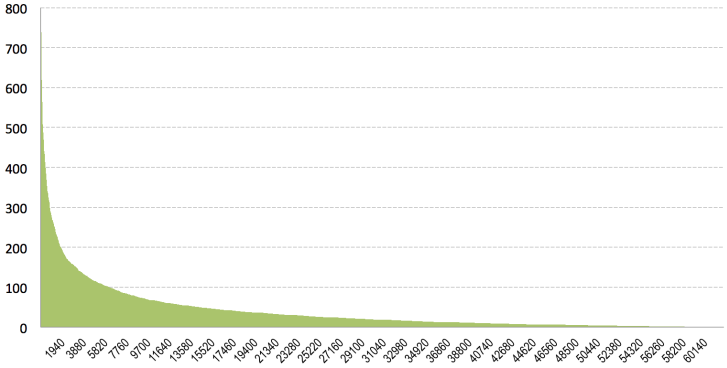
Contraints in ecology

Data from the real world is noisy,



Contraints in ecology

Data from the real world is noisy, unbalanced,



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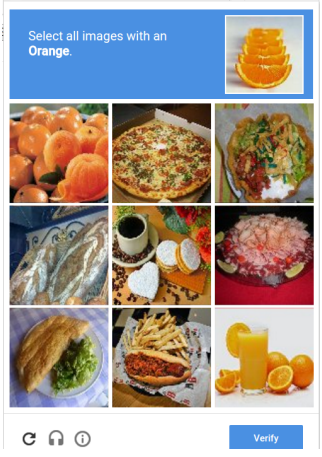

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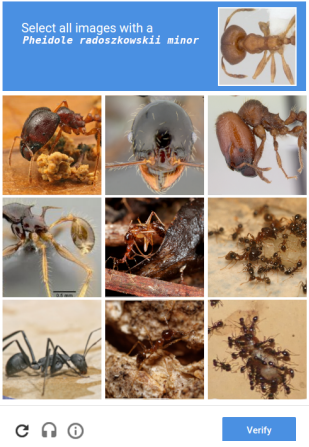
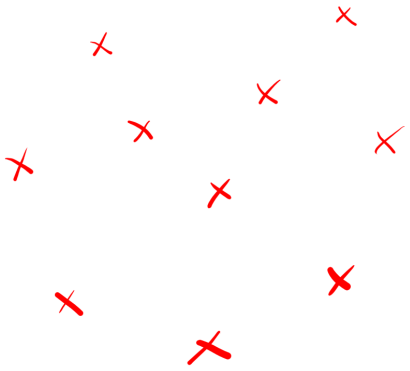
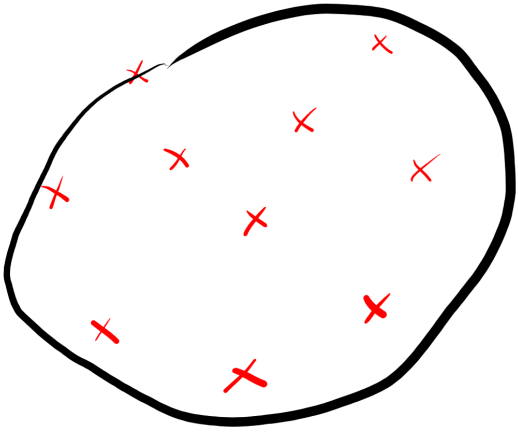
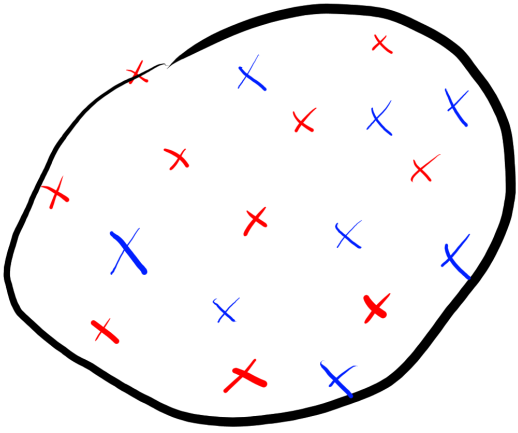




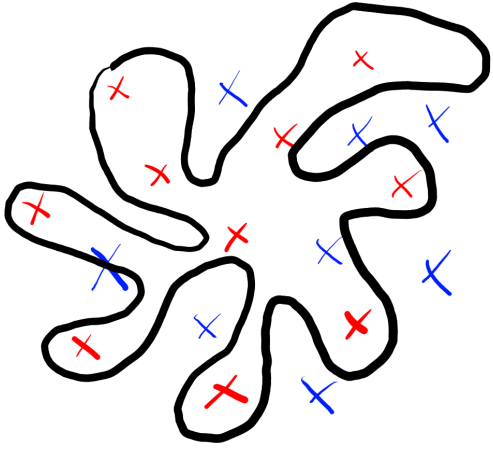
Train set



A good fitted model

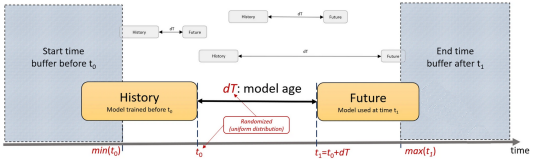


Test set



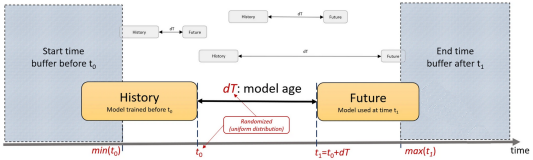
An overfitted model

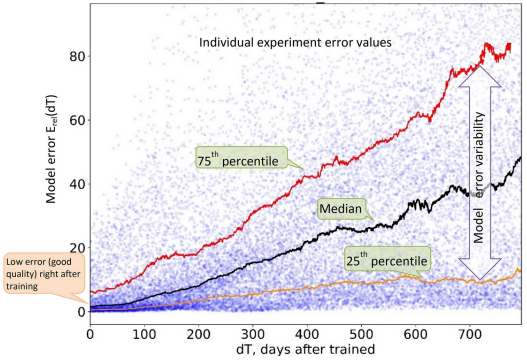
Out of distribution : Evolution with time



Adapted from Vela *et al.* 2022

Out of distribution : Evolution with time





Adapted from Vela *et al.* 2022

Out of distribution : Global changes

Conditions will evolve in never seen before conditions:

- Given ecosystem in unprecedented climatic conditions

Out of distribution : Global changes

Conditions will evolve in never seen before conditions:

- Given ecosystem in unprecedented climatic conditions
- Species migrate/invade in new territories

Out of distribution : Invasive species

New unknown species in the training test appears in a region.

- False Positive : confusion with known species

Out of distribution : Invasive species

New unknown species in the training test appears in a region.

- False Positive : confusion with known species
- False Negative : model misses the new species

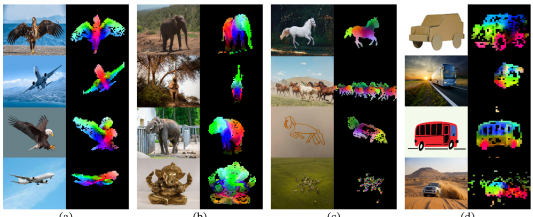
Out of distribution : Invasive species

New unknown species in the training test appears in a region.

- False Positive : confusion with known species
- False Negative : model misses the new species
- Handmade check on model confidence

How will it evolve ?

Models are more robust and generalist



- Self-supervised Learning (Pre-training)

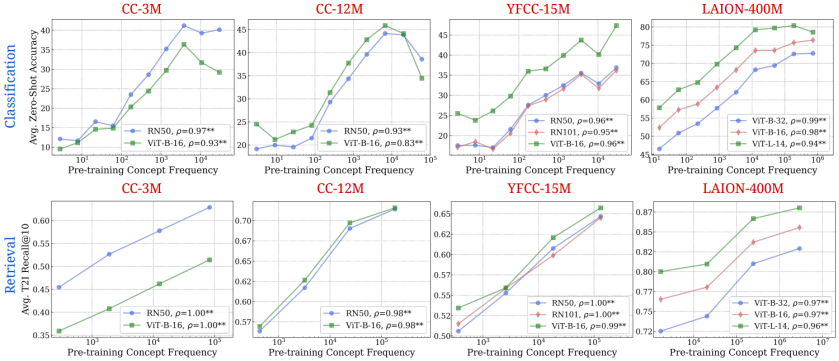
Oquab *et al.* 2024

Models are more robust and generalist

Oquab *et al.* 2024

- Self-supervised Learning (Pre-training)
- Better performances and robustness

Zero-shot at a cost



Udandarao *et al.* 2024

Conclusion

- Lots of potential
- But lots of traps

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➔ **Use wisely on the long term**

Thank you for your attention !

Any questions?