

# Artificial Intelligence in Ecology and Evolution : potential and limits

E2M2 webinar

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26/06/25

# 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 ?

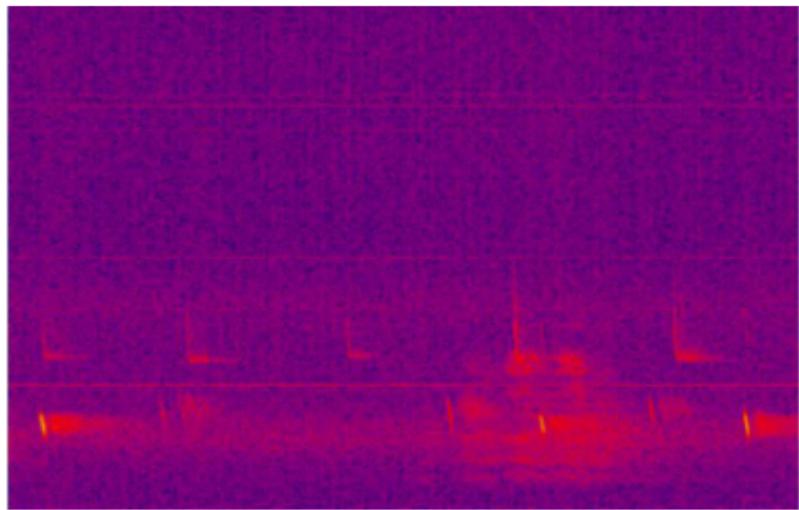
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## More and more data



- UAVs, Satellite

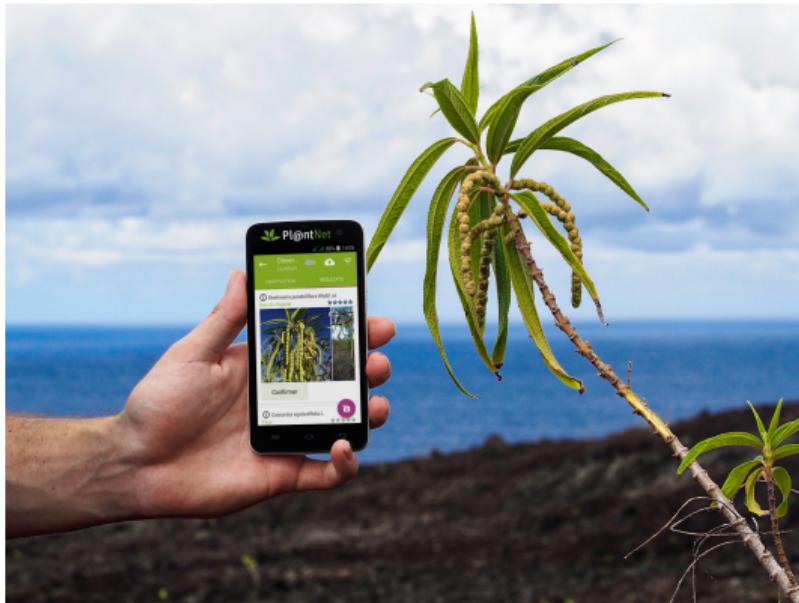
## More and more data



- UAVs, Satellite
- Camera trap, acoustic

Mac Aodha *et al.* 2022

## More and more data



[plantnet.org](http://plantnet.org)

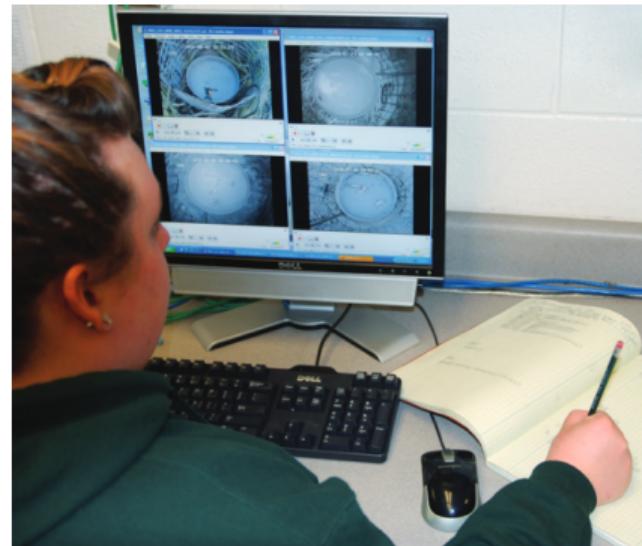
- UAVs, Satellite
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- Citizen science

## More and more data

- UAVs, Satellite
  - Camera trap, acoustic
  - 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

# Data analysis and interpretation is time consuming

- A computer does not sleep
  - A computer does not get tired
- **Automation now possible**



IN CS, IT CAN BE HARD TO EXPLAIN THE DIFFERENCE BETWEEN THE EASY AND THE VIRTUALLY IMPOSSIBLE.

xkcd 1425, 2014

**What are the cases where deep  
learning does work ?**

**and other models don't**

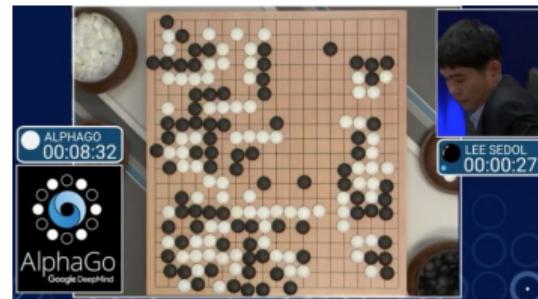
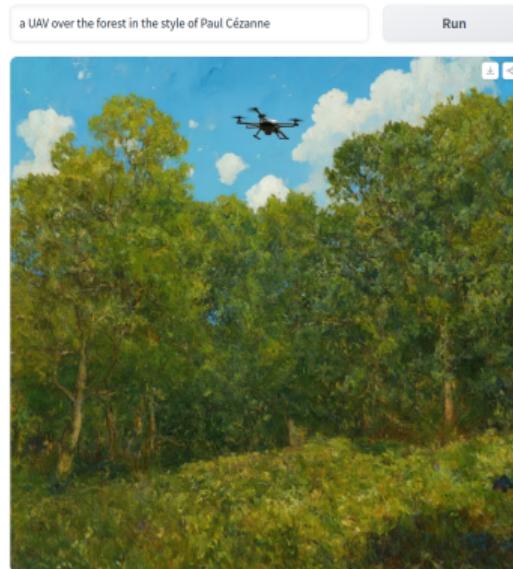
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## Model complex, non-linear and abstract relationships

Hi can you write me a haiku about forest with a subtle reference to Asterix ?

 Tall trees whispering,  
Mischief stirs in Gaulish woods—  
Magic roots run deep.



# Interpolation and generalisation



*Unonopsis stipitata* Diels

PlantClef 2020 Dataset

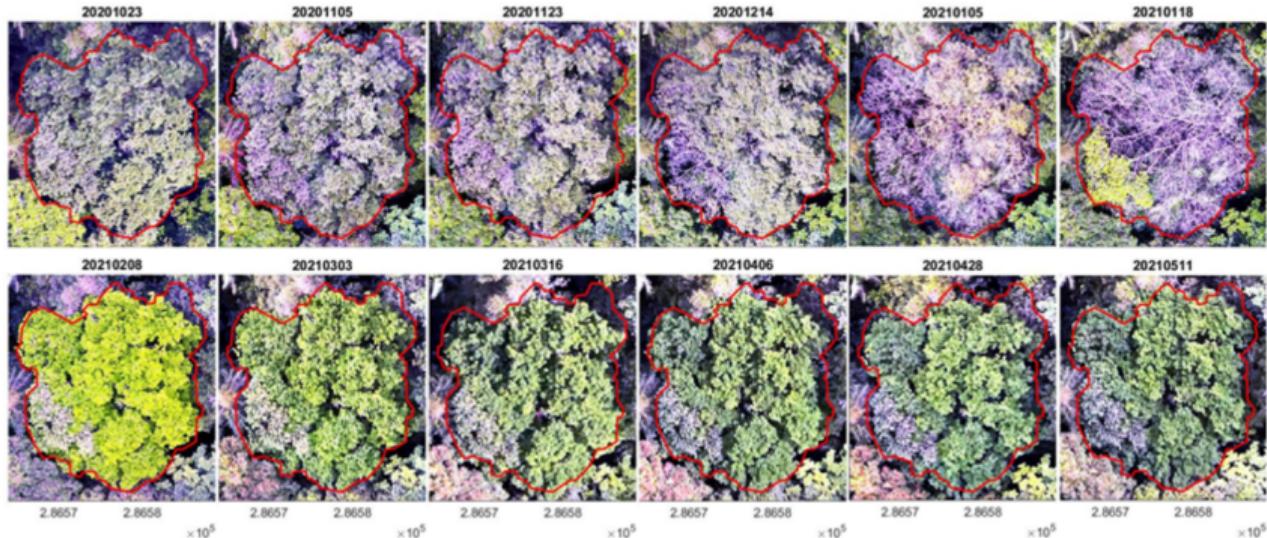
## What are the cases where deep learning doesn't work ?

Common traps when working with living things

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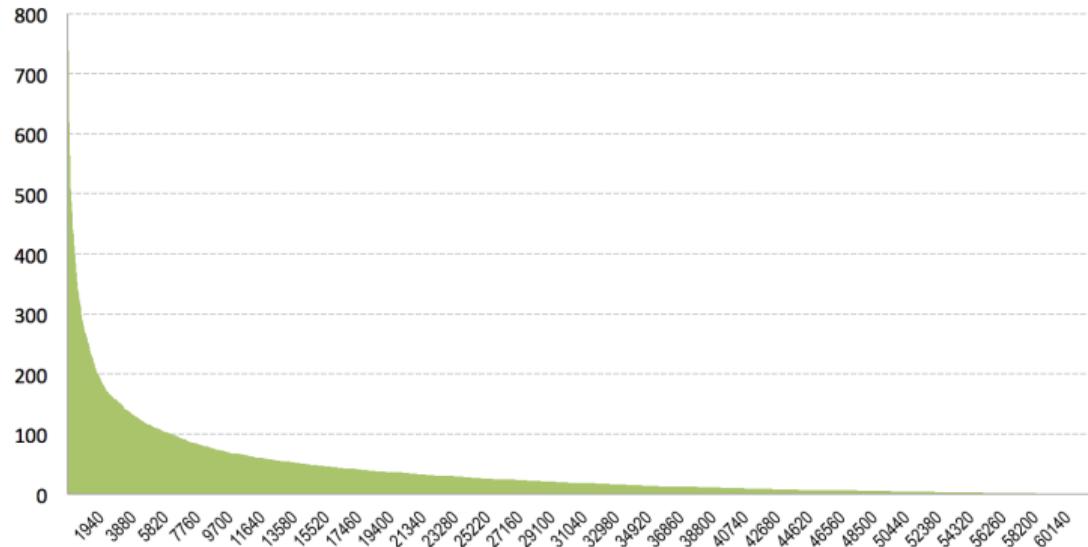
# Constraints in ecology

Data from the real world is noisy,



# Constraints in ecology

Data from the real world is noisy, unbalanced,



## Constraints in ecology

Data from the real world is noisy, unbalanced, hard to collect,



# Constraints in ecology

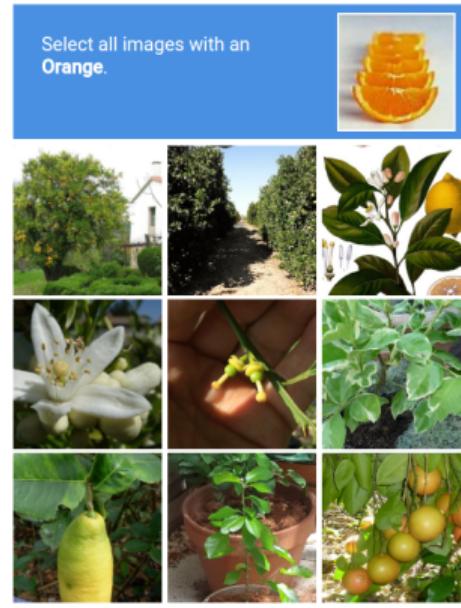
Data from the real world is noisy, unbalanced, hard to collect, hard to interpret.

Select all images with an Orange.

C    Verify

# Constraints in ecology

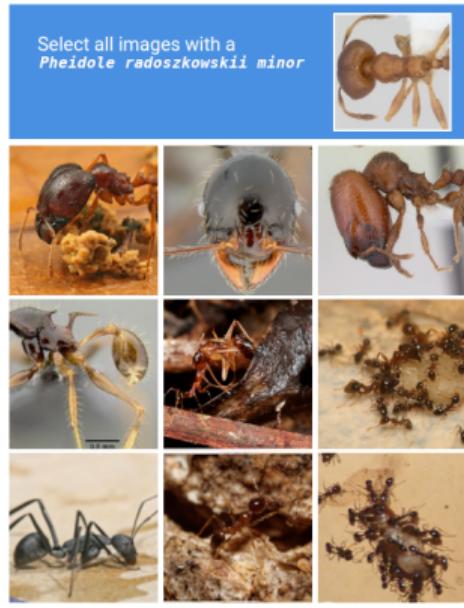
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# Constraints in ecology

Data from the real world is noisy, unbalanced, hard to collect, hard to interpret.

Select all images with a  
*Pheidole radoszkowskii minor*



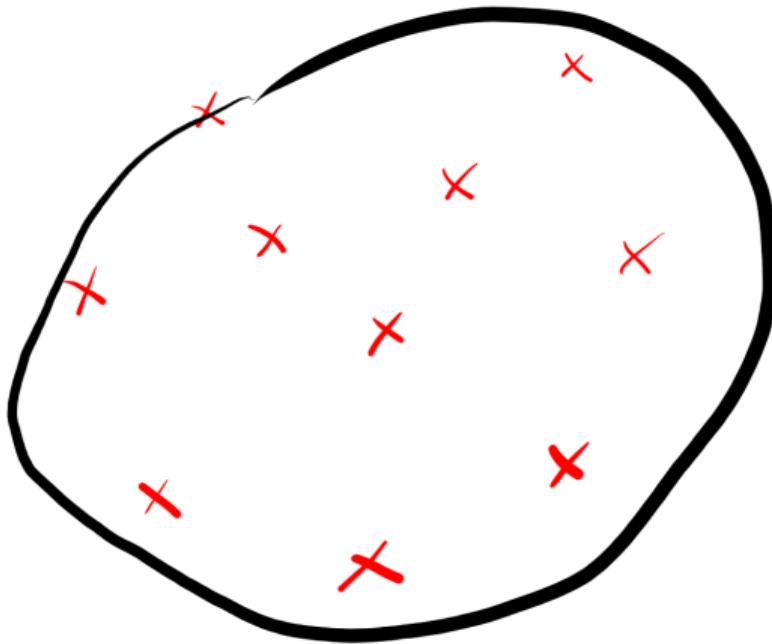
The grid contains nine images of ants, likely Pheidole radoszkowskii minor, used for a classification task. One image in the top row is a reference image of a single ant. The other eight images show various groups of ants or ants interacting with their environment, including close-ups of heads and legs, and larger groups on surfaces.



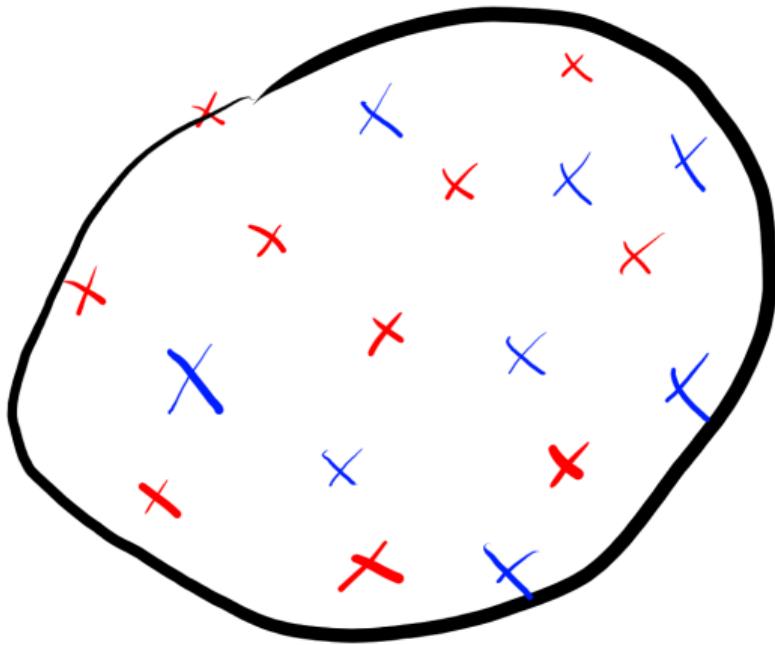
Verify



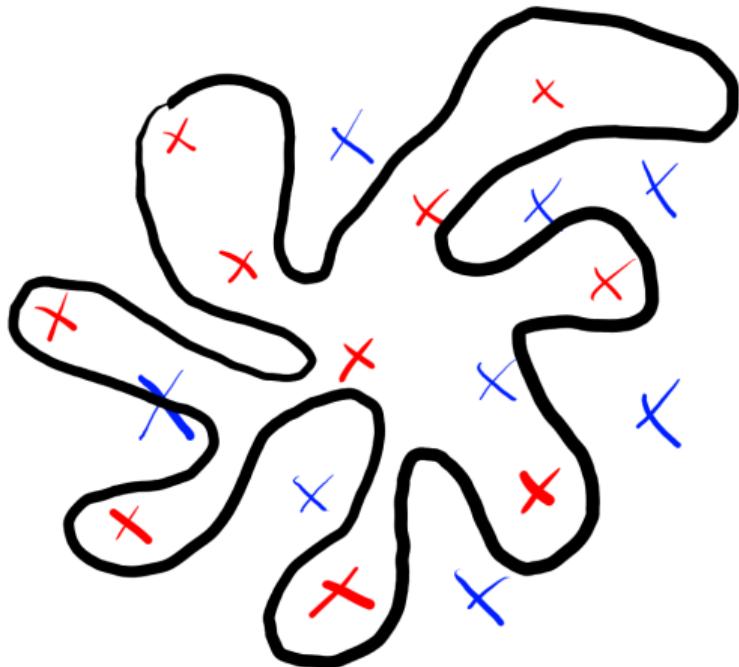
Train set



A good fitted model

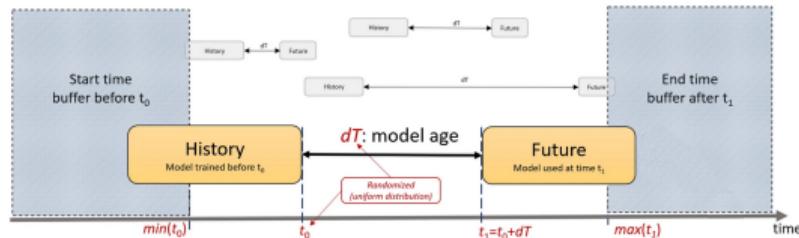


Test set



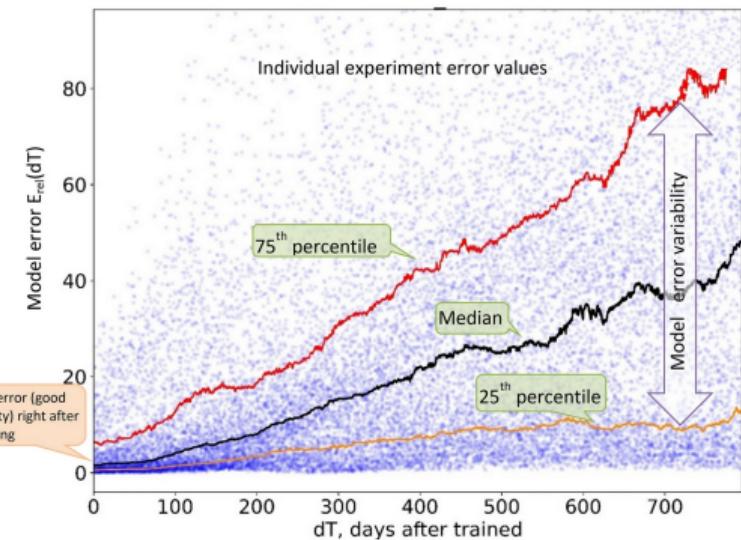
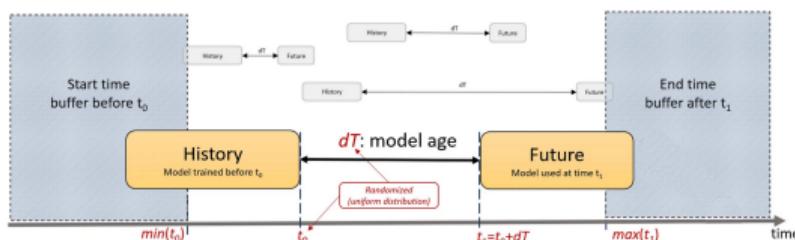
An overfitted model

# Out of distribution : Evolution with time



Adapted from Vela et al. 2022

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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/invoke 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

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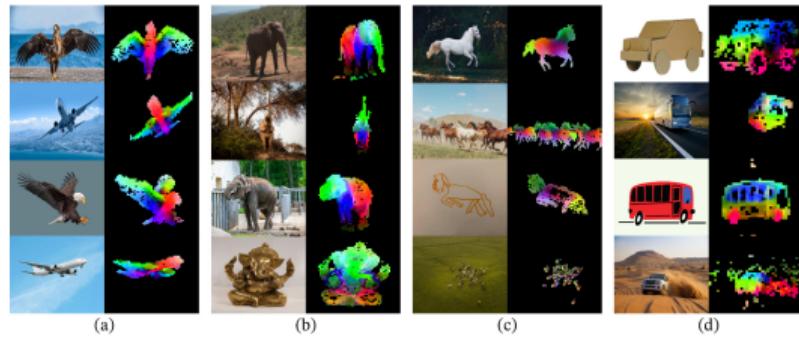
New unknown species in the training test appears in a region.

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

## How will it evolve ?

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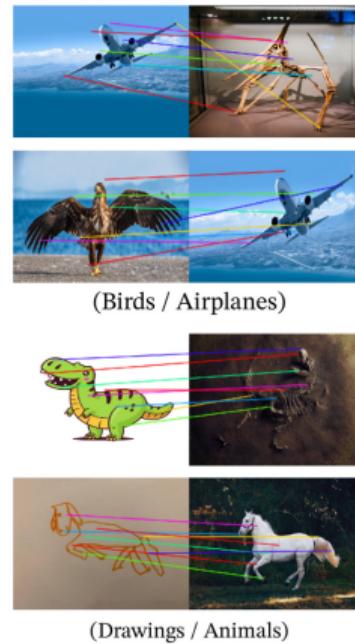
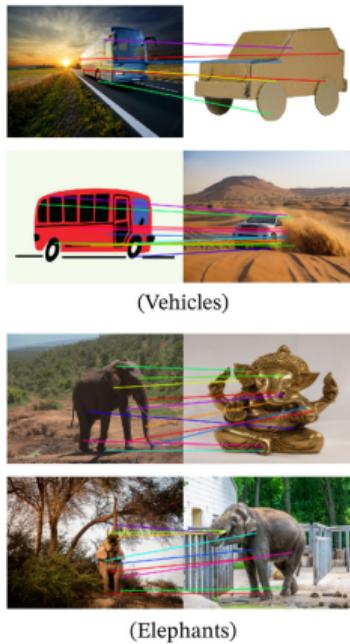
# Models are more robust and generalist



- Self-supervised Learning (Pre-training)

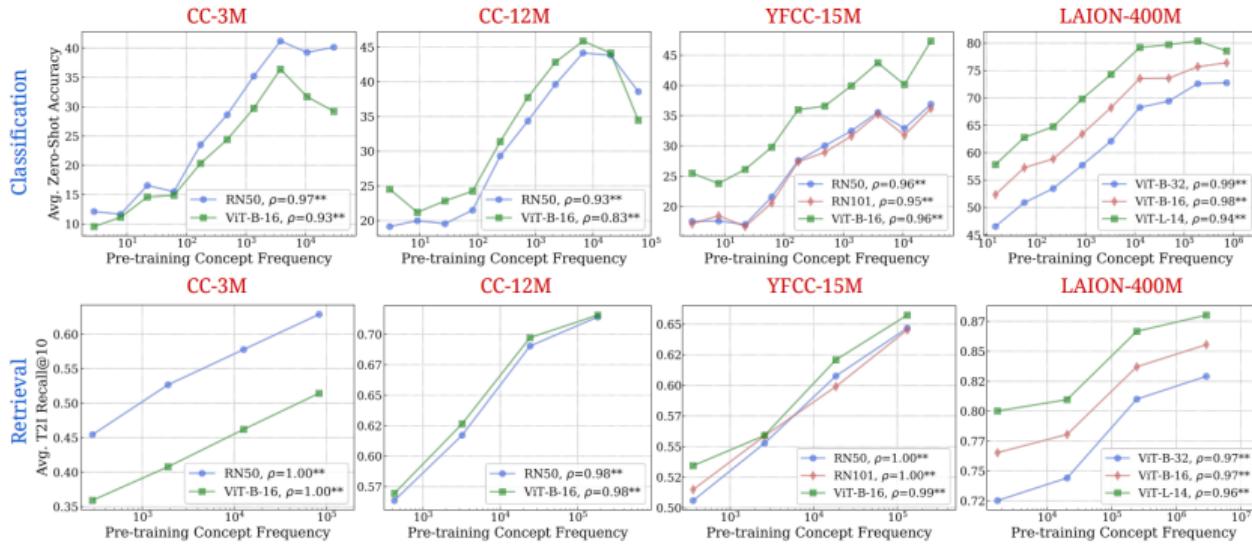
Oquab *et al.* 2024

# Models are more robust and generalist



- 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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- Lots of potential
  - But lots of traps
- **Use wisely on the long term**

Thank you for your attention !

Any questions?