ROBOTICS & AI in CONSERVATION ECOLOGY

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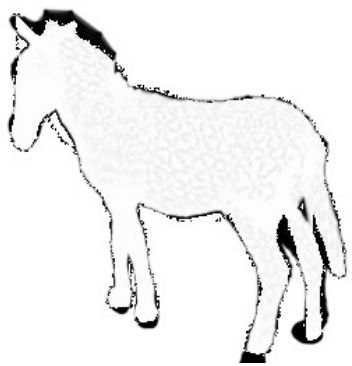
Source: CSIRO



ROBOTICS & AI

- Conservation **biologists & ecologists** are using **technologies** to aid their investigations and work
- **Robots** (platform - aerial, land or underwater - but also sensors) can collect **data** to generate new fundings, support ecological studies, habitat monitoring, behavior understanding, conservation policies, etc.
- **Robots** can operate in environments that are highly complex and rapidly changing
- In conservation ecology there are scenarios which have tasks that are difficult to be automated and where speed, subjectivity, versatility and robustness are fundamental: **AI could support this**!
- **Robots + AI inferences** can deliver added-value data, support decisions and offer innovative discoveries for biologists and ecologists
- A better **cooperation between robotics, AI & conservation sectors** can enhance monitoring & safeguarding of ecosystems, mitigate human “intervention” in wildlife, optimize management & promote a sustainable coexistence of humans & wildlife

ROBOTICS

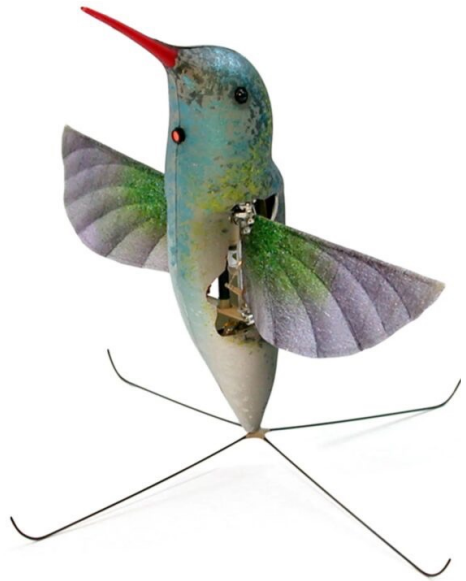
Anymal, Anybotics

Weaver Hexapod robot - CSIRO

RoBird - Aerium Analytics

Carnegie Mellon University

CSIRO



AeroVironment

ROBOTICS - seed-dropping / reforestation

AirSeed - https://www.youtube.com/watch?v=F6j08_F-hvQ

ROBOTICS - seed-dropping / reforestation

Morphing Matter Lab - “Erodium Copy" robot - https://www.youtube.com/watch?v=Omh8Sk4LhVo

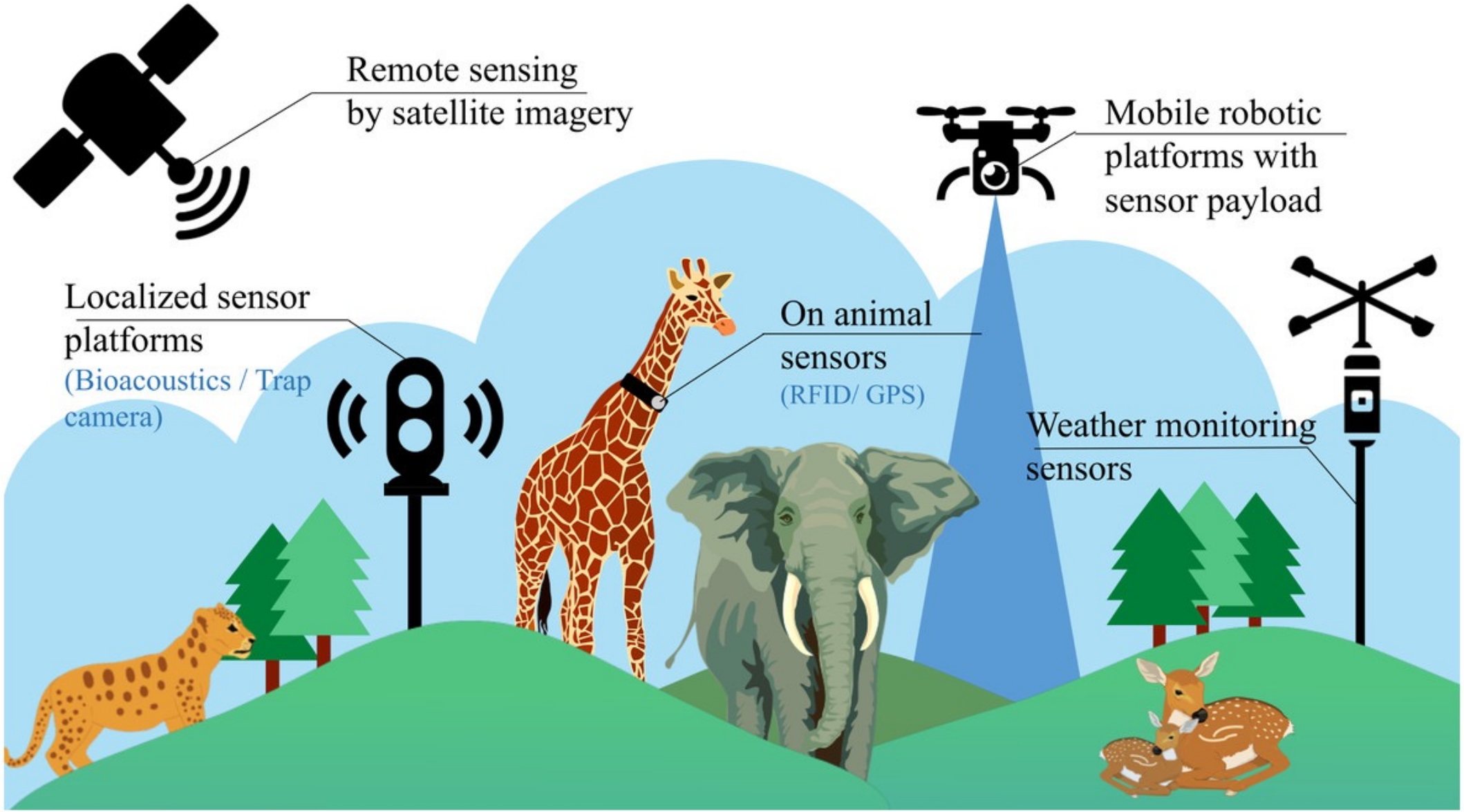
ROBOTICS - Spy Hummingbird

BBC Spy in the Wild - https://www.youtube.com/watch?v=Hq3X60H7aBo

SENSORS

[Tuia et al., 2022: Perspectives in machine learning for wildlife conservation. https://www.nature.com/articles/s41467-022-27980-y]

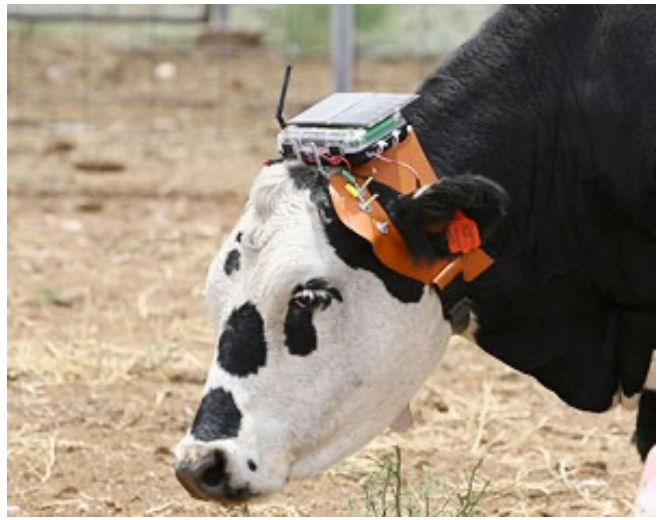
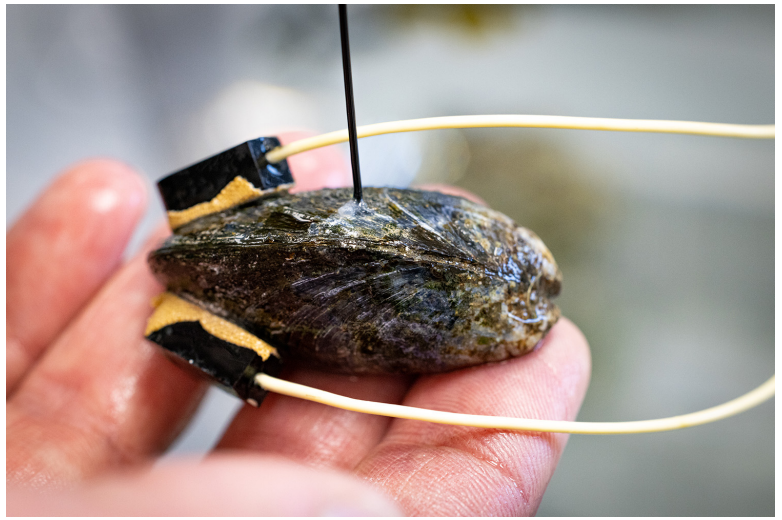
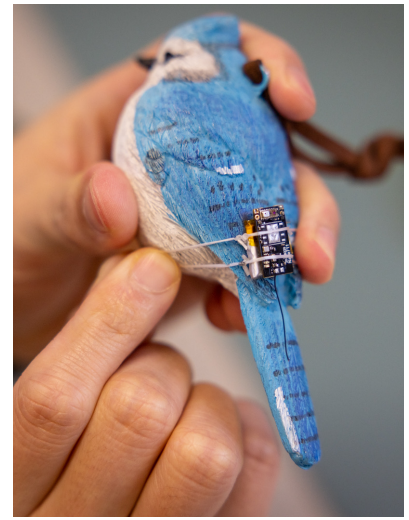
SENSORS

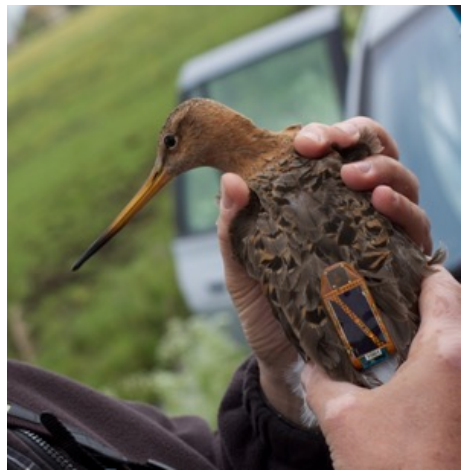


[Panigrahi et al., 2023: Real-time biodiversity analysis using deep-learning algorithms on mobile robotic platforms. DOI: 10.7717/peerj-cs.1502

SENSORS - on animals

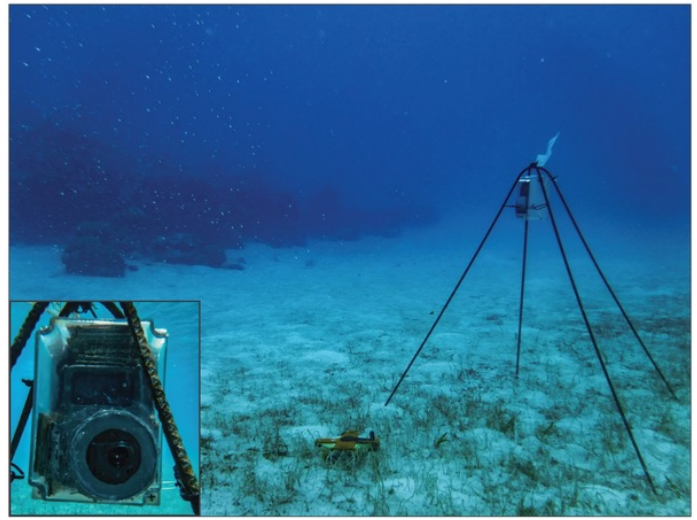
- Logging data to analyze movements, trajectories, speeds, heart rate, behavior, intrusions/poachers, etc.
- Limited to single individuals, GNSS (in)accuracy, battery, bandwidth, etc.


SENSORS - stationary

- Most common sensors to monitor biodiversity (ehm, if you are lucky…)
- Inexpensive, high-res, easy to use/install
- Limited field of view
- Data quality varies (blur, night/day, weather, etc.)
- Optical, acoustic



AI in CONSERVATION ECOLOGY

- AI is becoming a **powerful tool** in nature conservation e.g. for monitoring wildlife, behavior prediction, e-DNA collection, model human impact, etc.
- AI technologies & solutions are developing, but they need **"directions" & hints** from ecologists / conservators end-users to be better fine-tuned / customized for their sector / needs
- We need better ways to go **"from sensors to knowledge"**
- **Interdisciplinary and synergies** between fields can support better solutions and exploitation

Machine learning applied to **remote sensing** data for ecological & conservation purposes (e.g. **land cover**, **species identification** from satellite images, etc.), large-scale, low-resolution

1990s

First methods for **species identification** using terrestrial images, analyses of **acoustic data** to monitor wildlife (e.g. birds, marine mammals)

2000s

More momentum…
AI algorithms increasingly used for **image analysis**, **monitoring** of endangered species, **prevention** of poaching, **tracking**, etc.

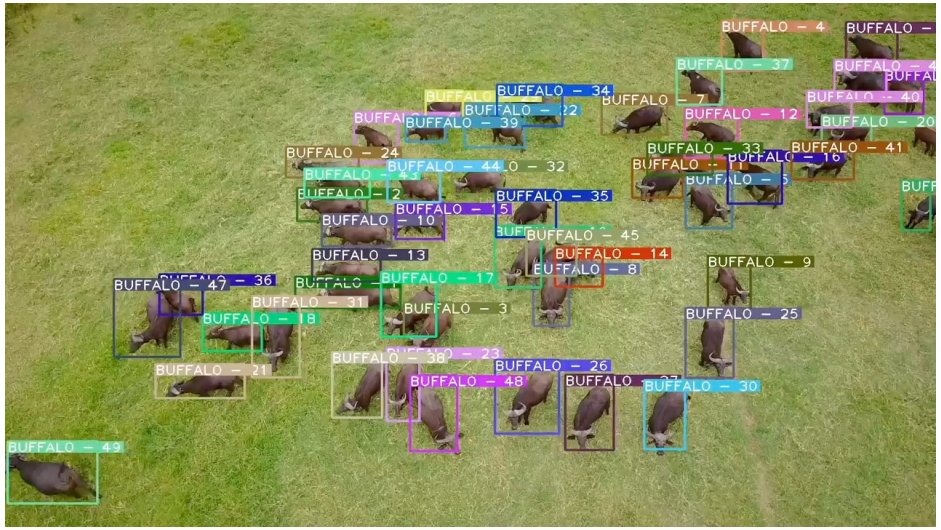
2010s

Data-driven
AI-powered tools, **predictive models** for biodiversity trends, habitat mapping, species identification, etc.
Large datasets, large trained models

2020s

AI solutions

- Image segmentation
- Object detection
- Point cloud classification
- Temporal planning
- Reinforcement learning
- ….
- *Monocular Depth Estimation (MDE)*
- *Neural Radiance Field (NeRF)*
- *Gaussian Splatting (GS)*



https://www.youtube.com/watch?v=9tLCFbupeOI

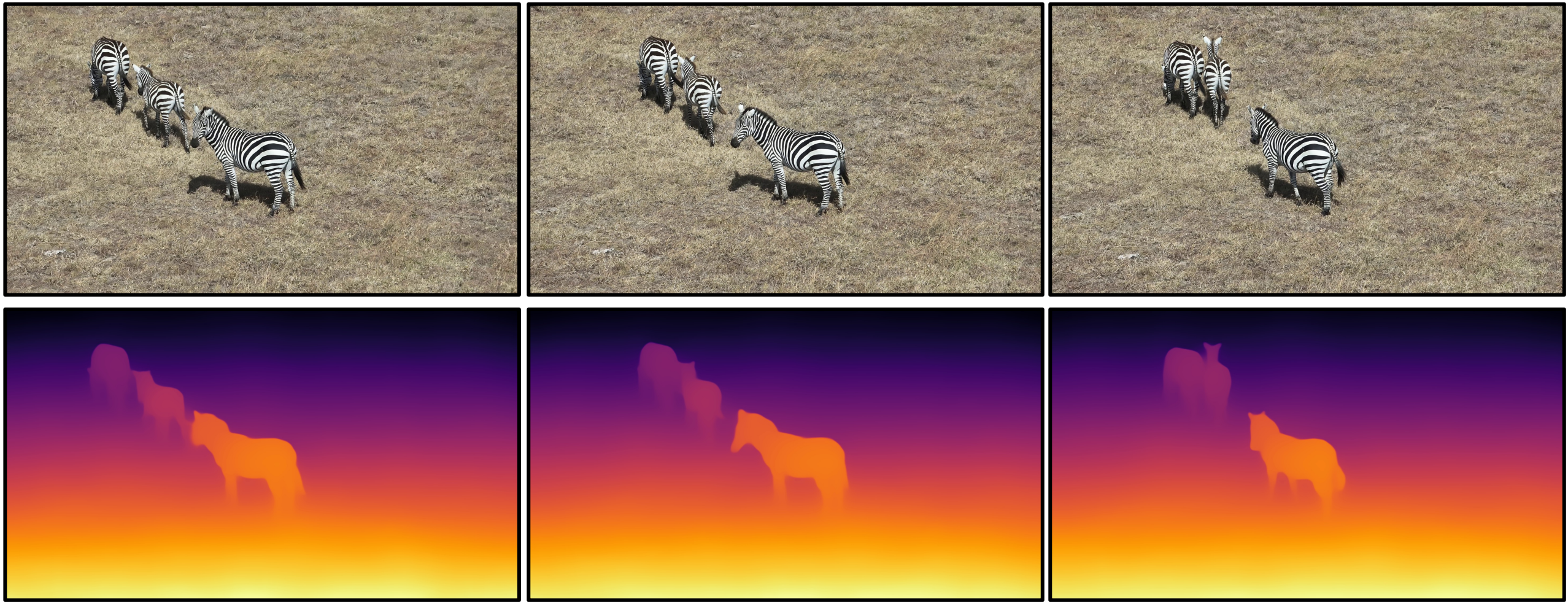
MONOCULAR DEPTH ESTIMATION (MDE)

MDE → retrieve depth of each pixel from a single image / view

- supervised or self-supervised
- encoder-decoder structure, use of visual transformers
- need of scale, in particular for self-supervised approaches
- **emerging**, useful in scene understanding, robots navigation, autonomous driving, textureless areas, lost (heritage) objects, etc.

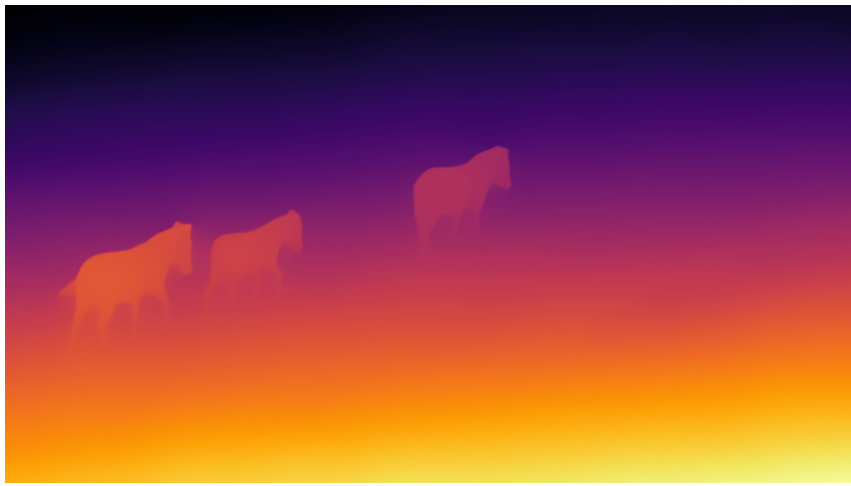
[Trybala, P., Remondino, F., Couciero, M., 2024: ***Towards robotization of foraging wild fruits: a multi-camera drone for mapping berries under canopy***. ERF / Springer proceedings]

MONOCULAR DEPTH ESTIMATION (MDE)



CHALLENGES / BARRIERS

- Concept of "**expensive hi-tech** with limited autonomy & intelligence"
- Find the **right task** for large-scale or repetitive actions
- **Skill requirement** of workers to operate such robotics/AI solutions
- **Regulations** making difficult to deploy fully autonomous robotics solutions (e.g. BVLOS)
- Create more **best practices** to promote Robotics & AI in conservation ecology
- **Close the gap** between IT/Robotics and ecologists to support effective development and use of automated solutions in conservation ecology
- Foster **interdisciplinarity**



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THANK YOU!!