Harmonious Coexistence: Ethical Issues Arising from Studies on Improving Plant Pollination with Micro-Drone Swarms, While Safeguarding Insect Populations and Fostering Human Health.

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Presentation by: **Matimba Swana**

PROTEAS Group

PROtecting The Earth with Autonomous Systems

A PhD student-led initiative that has grown to include engineers and researchers.

Mission

- To encourage and promote more **sustainable practices** in robotics and to provide **innovative solutions** to **environmental challenges** through state of art technology

How?

- Gather academics to address serious issues regarding climate change
- Collaboration between industries, academia and local authority
- Empower individuals through education and skill development

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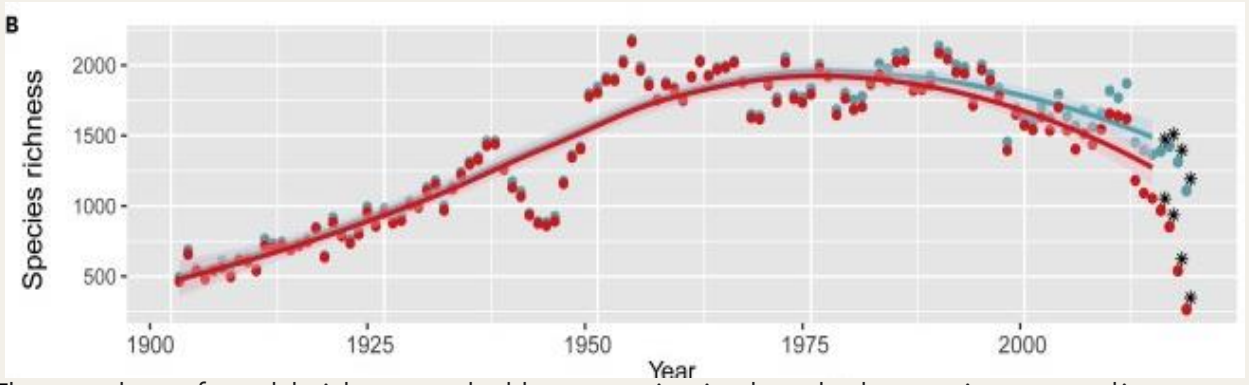
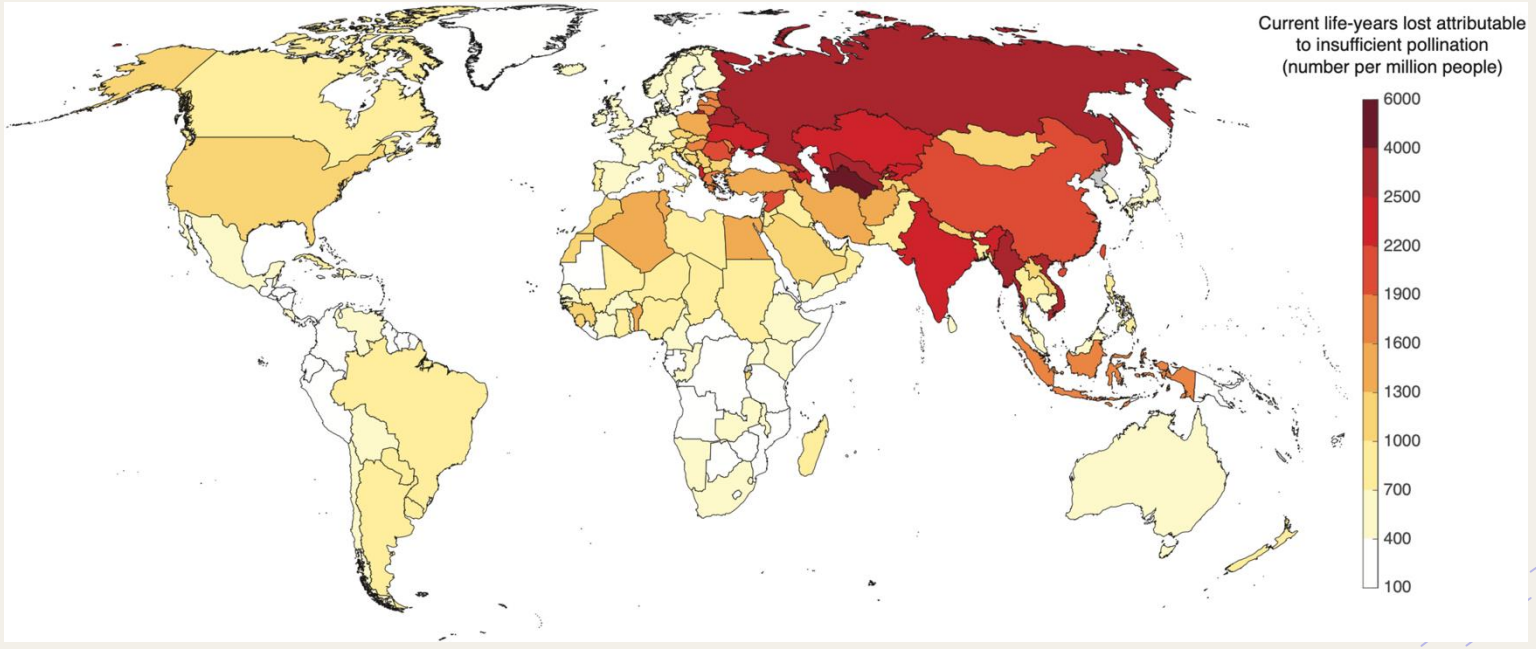
Pollination, climate change and human health



The number of worldwide recorded bee species is sharply decreasing according to GBIF dataset [Zattara, E. E., & Aizen, M. A. (2021).]

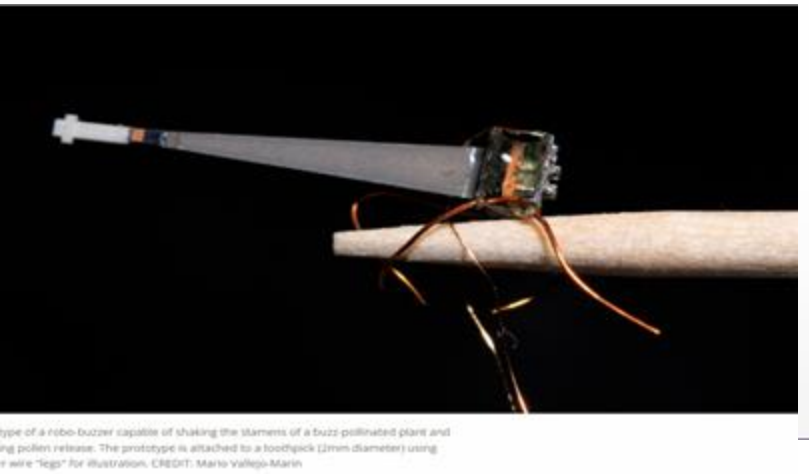
- Nutrition
- Medicine provisioning
- Mental health
- Environmental quality



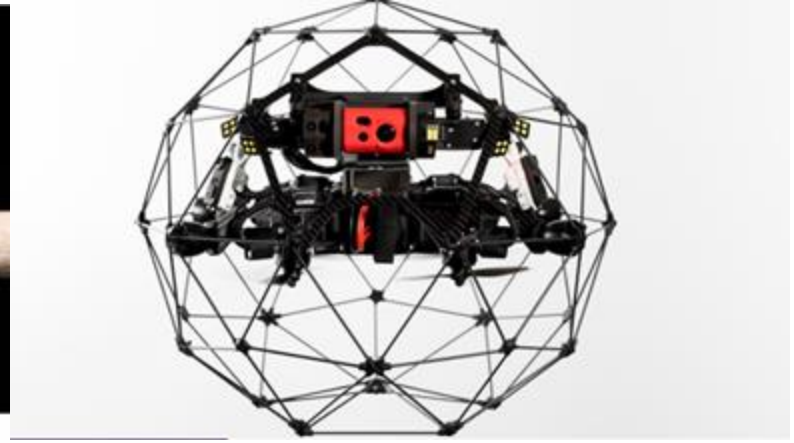
Life-years lost per capita estimated to be attributable to insufficient pollination. Insufficient-pollination-related health conditions include dietary and weight factors. Values represent median of model runs. [Smith et al. (2022)]

Human population
Food demand
Climate change

3-5% decrease in global food production due to reduced pollinators → 427,000 annual deaths from insufficient nutrition



ype of a robo-buzzer capable of shaking the stamens of a buzz-pollinated plant and
ng pollen release. The prototype is attached to a toothpick (2mm diameter) using
r wire "legs" for illustration. CREDIT: Mario Vallejo-Marin



Robot Pollinators

Almond Pollination using Bio-Inspired Control of Micro-Drone Swarms

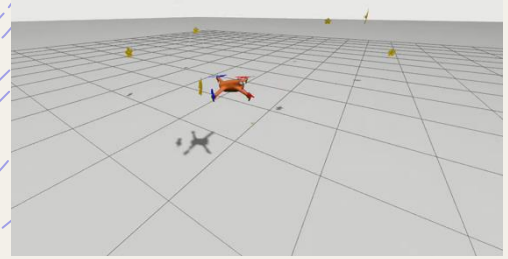
(Seedcorn Fund by Cabot Institute)

Cabot Institute for the Environment
Many minds, one mission

MICRO-UAV SWARM
Emergent of collective behavior from reactive agent to their local surrowndings

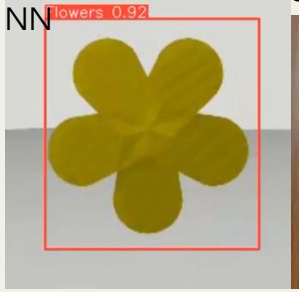
Single-Agent Performance

Gazebo Simulation



```
Terminal
python3 pollibee.py
Mission running in real mode
[INFO] [1714338531.126190066] [cf0.cf0_i
nterface]: Starting cf0
[INFO] [1714338531.665414101] [cf0.cf0_i
nterface]: cf0 interface initialized
Start mission
Arm
Offboard
Take Off
```

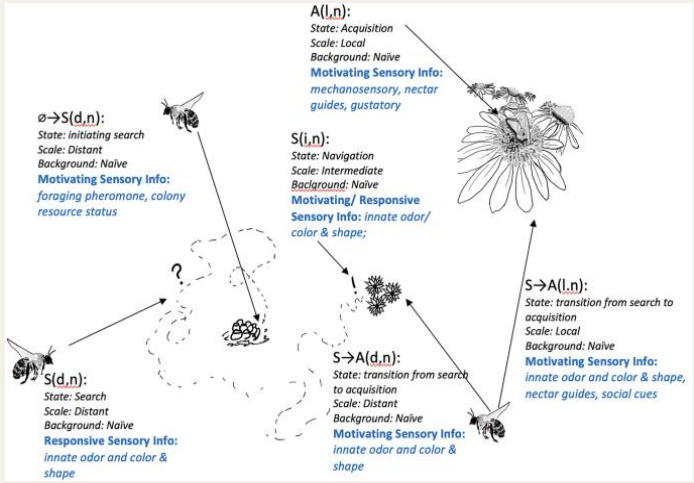
Image Recognition NN

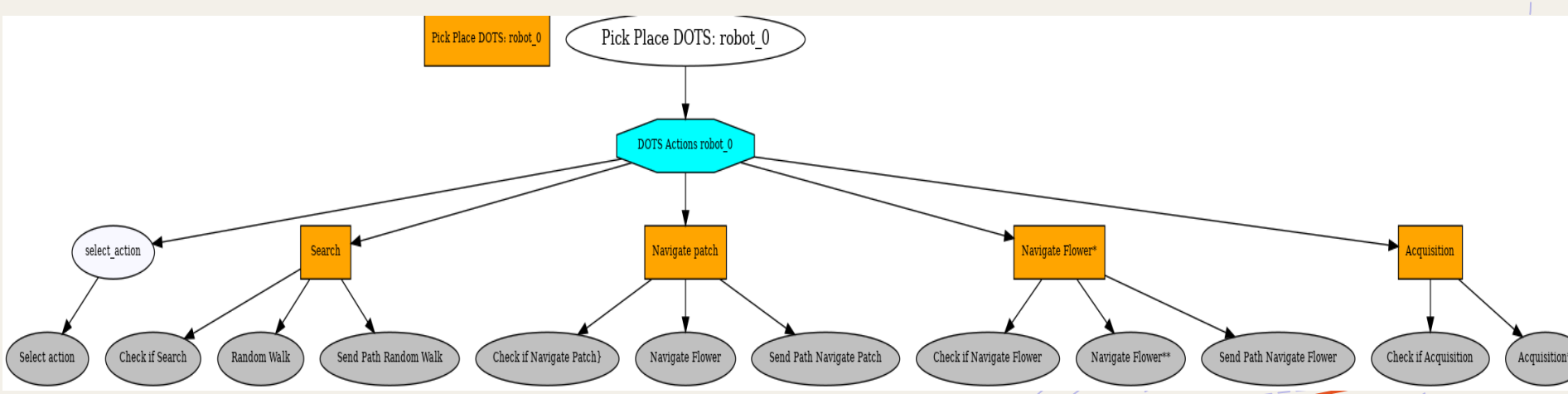


3D printed model

1. Approach flower with transit speed
2. Identify flower with inspection speed
3. Ready for pollen collection

Micro-UAV Swarm





The Team

+ ***Sustainability & Computer Systems***

Prof. Chris Preist

+ ***Ecology & Biology***

Jane Memmott, Christoph Grueter, Hannah Romanowski

+ ***Aerial Robotics & UAV Operations***

Prof. Tom Richrdson, Dr. Alex McConville

+ ***Swarm Robotics***

Prof. Sabine Hauert, Khulud Alharthi

+ ***Multi-Robot Systems***

Henry Hickson, Avgi Stavrou

+ ***Multi-UAV Systems***

Dr. Mickey Li, Georgios Tzoumas

+ ***Maritime Robotics***

Dr. Elliott Scott

+ ***Computational Modelling***

Daan Scheepen

+ ***Biology & Swarm Intelligence***

Matimba Swana

+ ***Ethics & FoodBioSystems DTP***

Kirsten Ayris

Collective Decision making (Humans)

Decision needs to be made collectively on:
Impact of UAV swarm pollination on biodiversity
The life cycles of deployed robots
The social implications of this approach

Human Robot Interaction Considerations

Safety & Hazards

+ Physical Interaction
+ Surveillance
+ Psychological impact

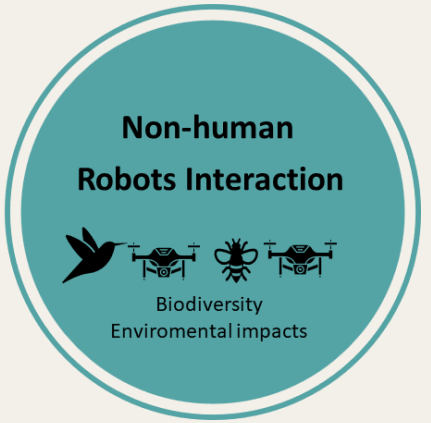
Security & Data Protection

+ Sensitive data collection
+ Real-time performance monitoring
+ Transparency & Cybersecurity

Socioeconomic factors

+ Labor impact & Human replacement
+ Access & Equity

Artificial pollinators to foster human health AND solve declining bee population



Dependence on technology

+ agriculture systems vulnerable to technical failures and cyber-attacks.
+ environmental impact of materials used in pollibots and their lifecycle.

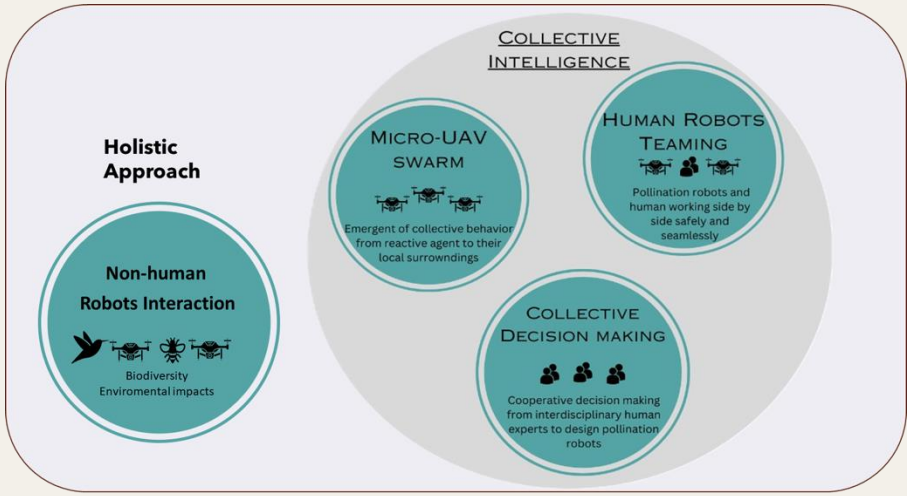
Biodiversity

+ focus on cash crops could neglect wild plants, decrease plant diversity and harm wildlife food sources
+ Animal consumption could disrupt ecosystems

Long-term Ecological Consequences

+ Unintended consequences
+ Research needed such as carbon footprint throughout their lifecycle
+ Combine with alternative pollination methods

Recommendations



Balance Human-Centred and Interspecies Design Thinking

+ Move from task focused to holistic approach
+ Highlight the vulnerability of natural pollinators through nonhuman-centred design exploration.
+ Integrate environmental, agricultural, and technological policies to enhance biodiversity.

Develop Responsibility by Design Practices

+ Implement "responsibility by design" to embed ethical and sustainability principles in robotic pollinator development.
+ Promote sustainability, inclusivity, and collaboration in design practices
+ Provide training on ecodesign, accessibility, and multispecies rights recognition

Concluding remarks

- **Interdisciplinary team discussions highlight the necessity for further research on:**
  - Impact of UAV swarm pollination on biodiversity.
  - Life cycles of deployed robots,
  - Social implications of this approach.
- **This work can be extended to:**
  - Field trials
  - Collaborate with social and environmental scientists and impacted communities
- **We are a dedicated to developing robotics that have a positive impact on the environment and society.**

Thank you for listening!

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References

- Zattara, E. E., & Aizen, M. A. (2021). Worldwide occurrence records suggest a global decline in bee species richness. One Earth, 4(1), 114-123
- Garibaldi LA., Gomez Carella DS., Nabaes Jodar DN., Smith MR., Timberlake TP. and Myers SS. (2022). Exploring connections between pollinator health and human health. *Philosophical Transactions Of the Royal Society B* 377: 20210158. DOI: 10.1098/rstb.2021.0158
- Miller-Struttmann, Nicole E. 2024. 'Climate Change Predicted to Exacerbate Declines in Bee Populations'. *Nature* **628** (8007): 270–71. DOI: 10.1038/d41586-024-00681-w
- Smith MR, Mueller ND, Springmann M, Sulser TB, Garibaldi LA, Gerber J, Wiebe K, Myers SS. (2022) Pollinator Deficits, Food Consumption, and Consequences for Human Health: A Modeling Study. *Environ Health Perspect*. **130**(12), 127003. DOI: 10.1289/EHP10947.
- Lisbona, N (2023). Farmers turn to tech as bees struggle to pollinate. BBC. https://www.bbc.co.uk/news/business-66807456 [accessed 17th September 2024]
- [PROTEAS. Pollibots. https://sites.google.com/view/proteas/projects/pollibots [accessed 17th September 2024]
- Chechetka S A, Yu Y, Tange M, Miyako E. (2017) Materially Engineered Artificial Pollinators. Chem 2(2), 224-239. DOI: 10.1016/j.chempr.2017.01.008
- Broussard, M.A.; Coates, M.; Martinsen, P. (2023) Artificial Pollination Technologies: A Review. *Agronomy.* **13**, 1351. DOI: 10.3390/agronomy13051351
- Sparrow, R., Howard, M. (2021) Robots in agriculture: prospects, impacts, ethics, and policy. *Precision Agric*. **22**, 818–833. DOI 10.1007/s11119-020-09757-9
- [Potts SG, Neumann P, Vaissière B, Vereecken NJ. (2018) Robotic bees for crop pollination: Why drones cannot replace biodiversity. *Sci Total Environ*. **15**:642, 665-667. DOI: 10.1016/j.scitotenv.2018.06.114. Epub 2018 Jun 14. PMID: 29909334.
- Figliozzi MA (2017) Lifecycle modeling and assessment of unmanned aerial vehicles (Drones) CO2e emissions. *Transportation Research Part D: Transport and Environment*. **57**, 251-261 DOI: 10.1016/j.trd.2017.09.011.
- Price, C. (2023). Do we need Artificial Pollination if we have Multispecies Justice in the Anthropocene?. Exchanges: The Interdisciplinary Research Journal, 10(2), 50-73. https://doi.org/10.31273/eirj.v10i2.966