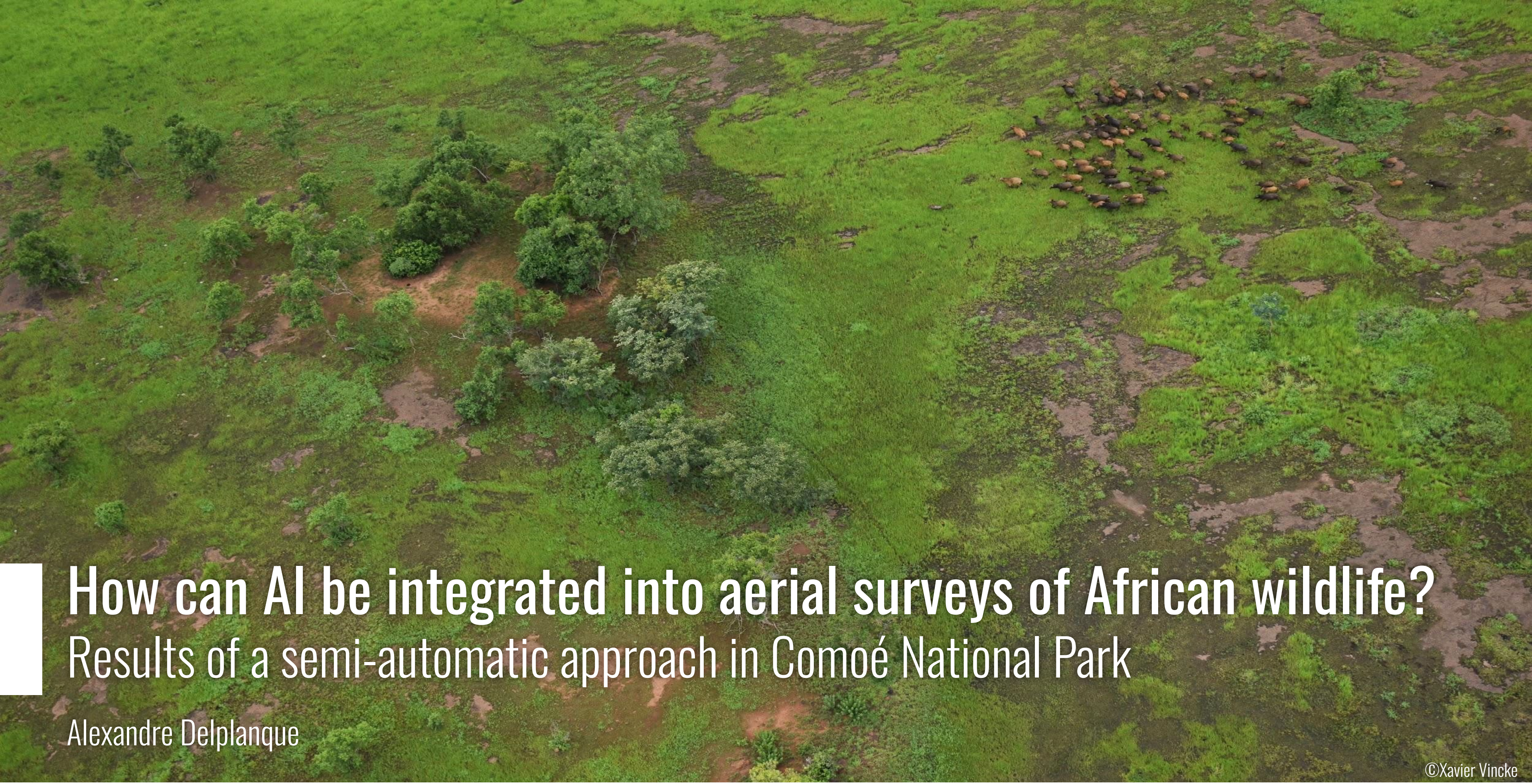

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How can AI be integrated into aerial surveys of African wildlife?

Results of a semi-automatic approach in Comoé National Park

Alexandre Delplanque

Journée de conférences “Étude et conservation de la faune en milieux tropicaux et tempérés” on November 13, 2023

LIÈGE université Gembloux Agro-Bio Tech · UdS Université de Sherbrooke · AVIATION SANS FRONTIÈRES ASF BELGIUM · OIPR · fnrs FREEDOM TO RESEARCH

Context

Biodiversity loss is still accelerating

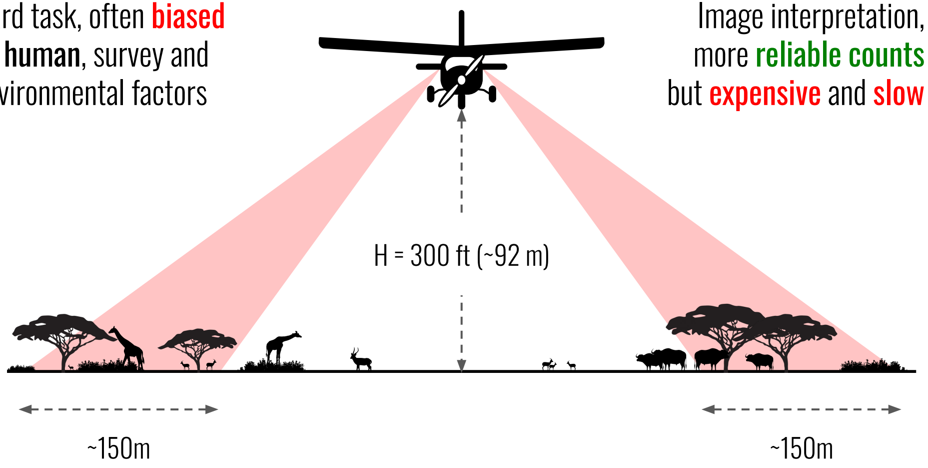
↳ Effective assessment relies on tracking key-species populations with standardized data

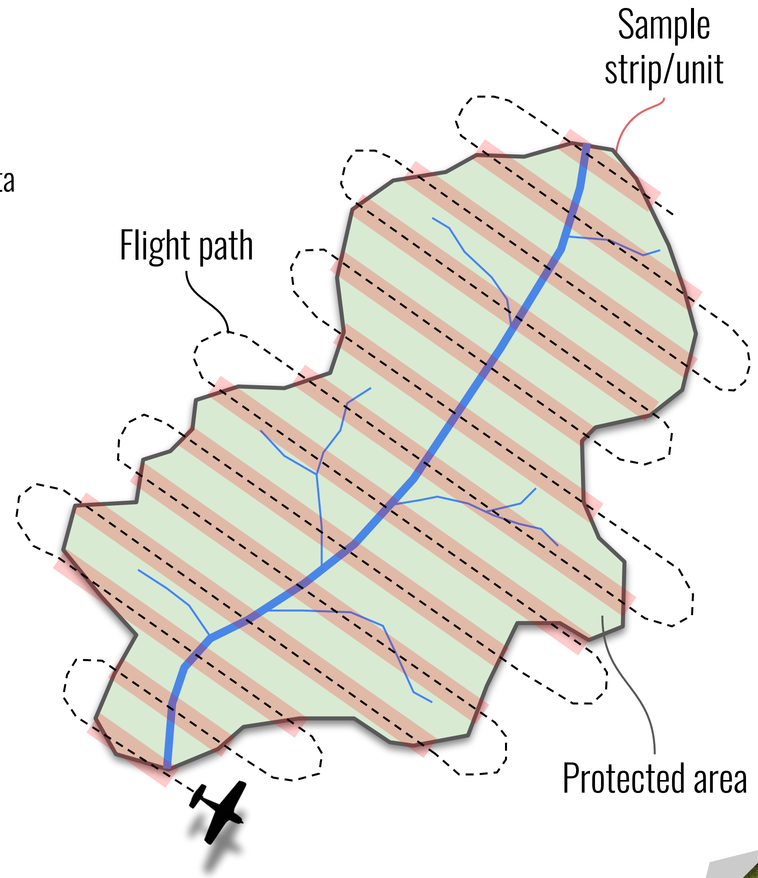
In Africa, counting large wildlife species relies on the **SRF[1] method**

RSOs[2]: on-sight count → **OCC[3]: photo count**

Hard task, often **biased** by **human**, survey and environmental factors

Image interpretation, more **reliable counts** but **expensive** and **slow**



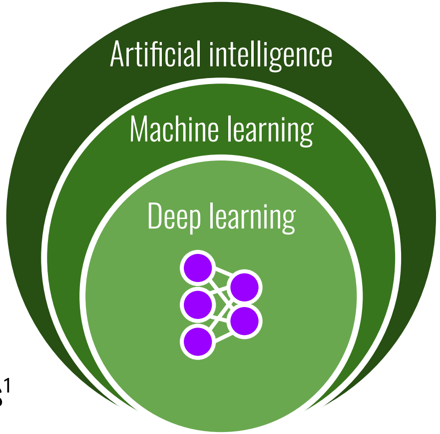


[1]SRF, Systematic Reconnaissance Flight; [2]RSO, Rear Seat Observer; [3]OCC, Oblique Camera Count

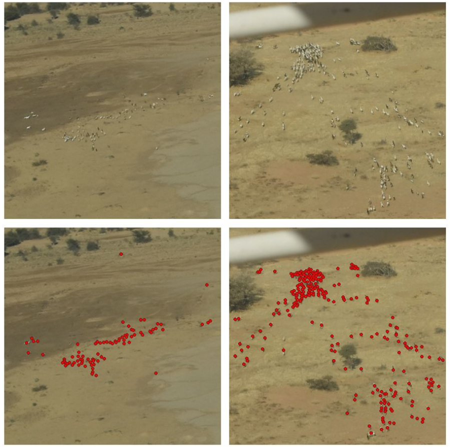
New insights with AI

RSOs: on-sight count → **OCC: photo count** → **AI: detection check**

- **RSOs: on-sight count** — Hard task, often **biased** by **human**, survey and environmental factors
- **OCC: photo count** — Image interpretation, more **reliable counts** but **expensive** and **slow**
- **AI: detection check** — Automated image processing, **reliable?** **Less expensive, faster?**



DL-based object detection approaches showed good prospects for large-scale use of AI in aerial survey!



BUT

- High false positive rate
- Rare species poorly detected
- Too limited and specific dataset > data gap between PAs[1]

Strong need for efficient DL model integration

Q1 Does a semi-automated approach requiring minimal human effort detect more animals than observers?

Q2 Do the results of such an approach improve population estimates?

[1]PA, Protected Area

Study area & Aerial survey

Study area | The Comoé National Park, in Côte d'Ivoire

Area | ~11 500 km^2

Vegetation | Transitional habitats between forest and savannah

Target species | Western hartebeest, buffalo, kob, waterbuck, elephant, roan antelope and warthog

Survey design | Sample rate of ~13%

- 156 transects (i.e. sample units) - 2 km spacing
- 4 strata: NW, NE, SW and SE
- 12 days, 54 flight hours
- Flying crew: pilot, FSO, 2 RSOs, photo manager

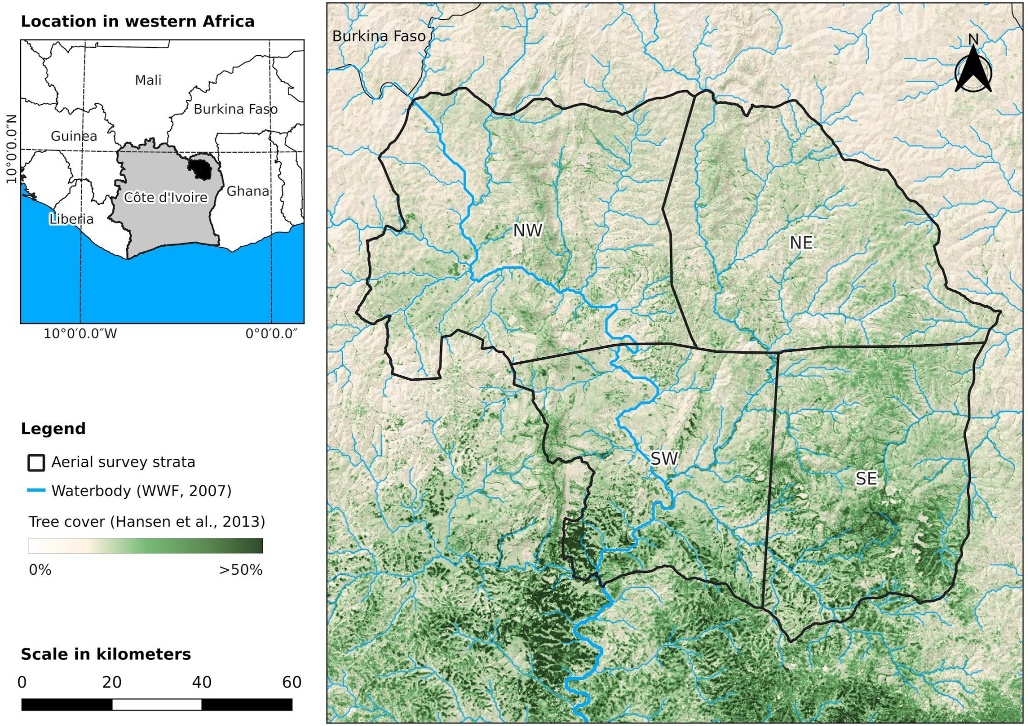


Image acquisition

2 Nikon D5600 oblique cameras

Similar to viewing angle of RSO

Acquisition of 24MP[1] image, each 2s

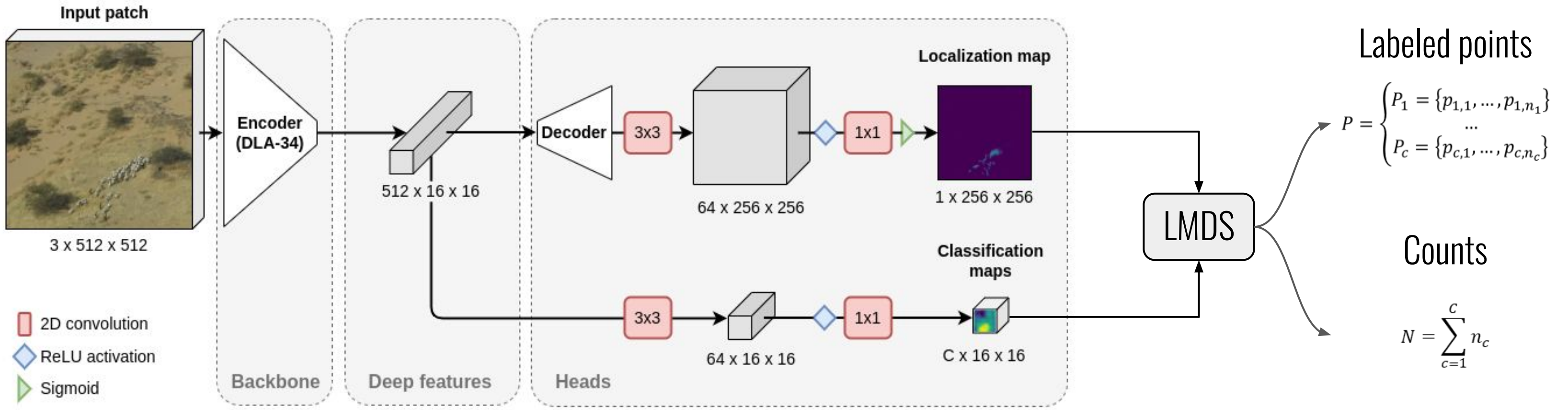
Total of **148 239 transect images**

[1]MP, Megapixel

Deep learning model

Access the code and paper!

HerdNet[1], a point-based object detector which showed better performance than common DL architecture

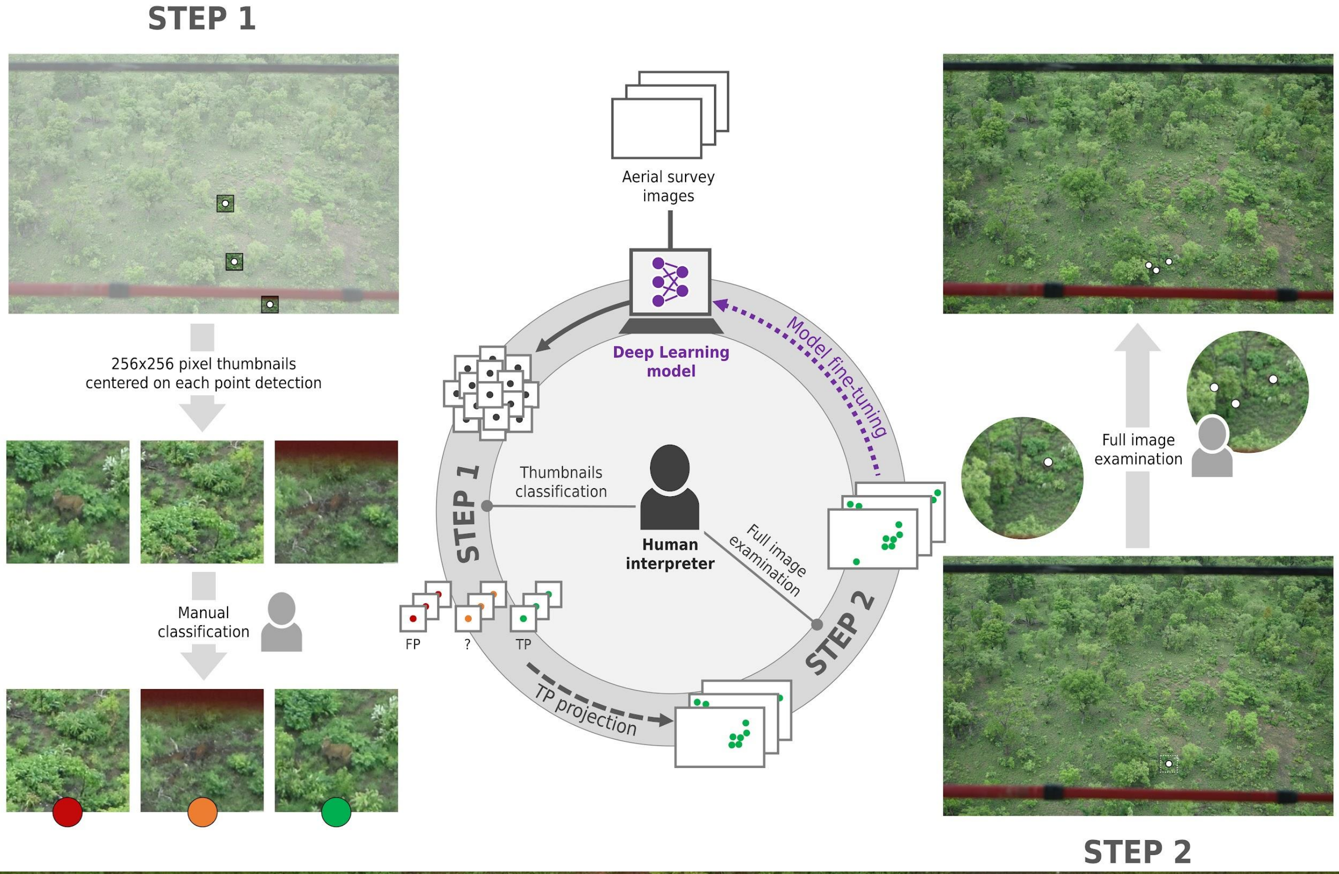


$$P = \begin{cases} P_1 = \{p_{1,1}, \dots, p_{1,n_1}\} \\ \dots \\ P_c = \{p_{c,1}, \dots, p_{c,n_c}\} \end{cases}$$

$$N = \sum_{c=1}^{C} n_c$$

[1]Delplanque, et al. (2023). From crowd to herd counting: How to precisely detect and count African mammals using aerial imagery and deep learning? ISPRS Journal of Photogrammetry and Remote Sensing, 197, 167–180. https://doi.org/10.1016/j.isprsjprs.2023.01.025

Semi-automated image processing



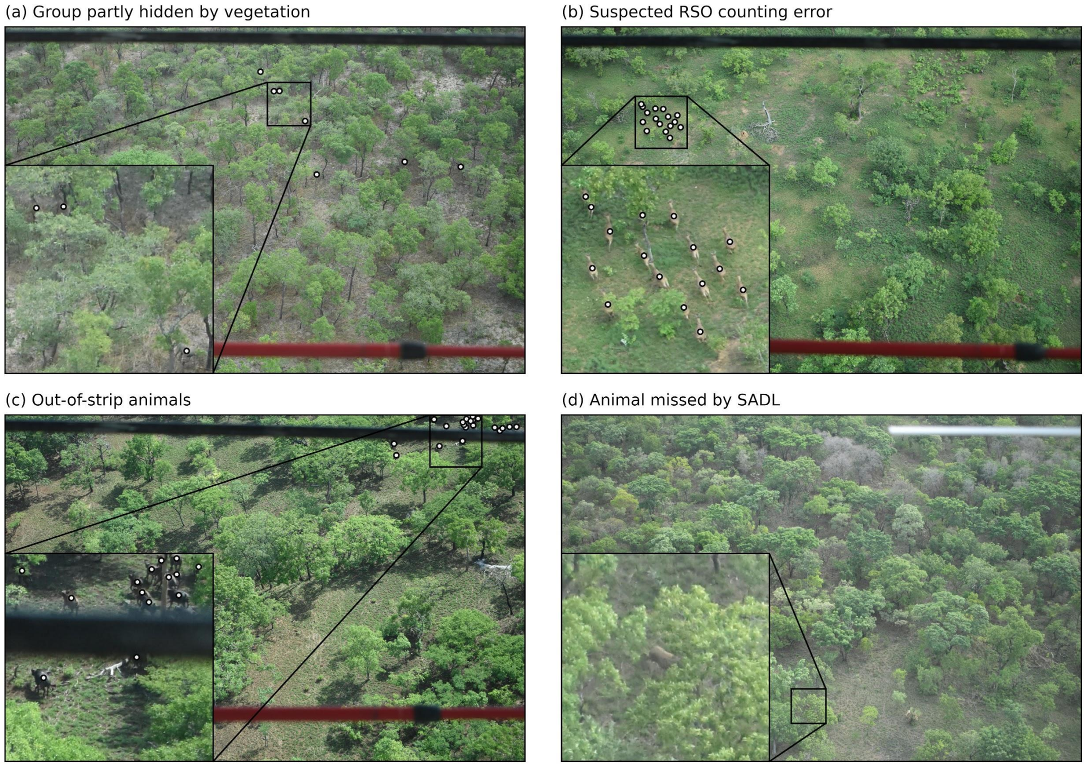
Data analysis

Population estimate | Stratified Jolly II analysis for unequal sized sample units

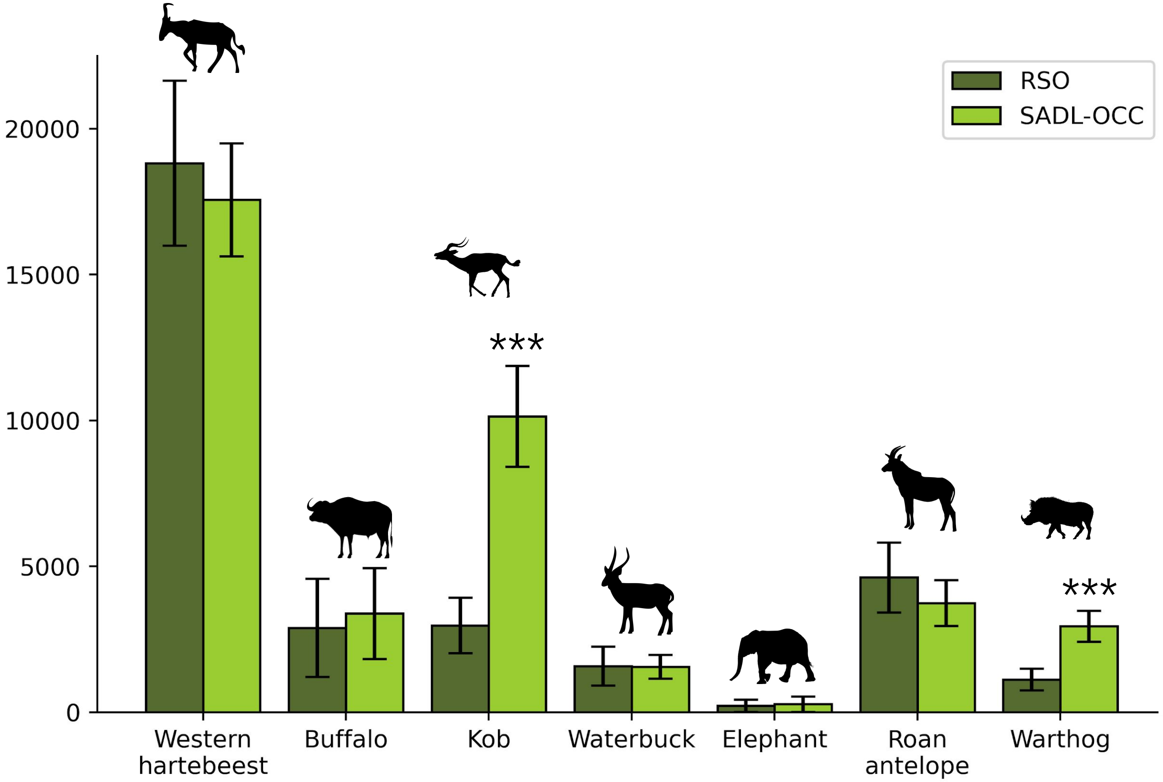
RSO vs. Semi-auto DL model | t-test - H0: Estimates are not significantly different (α=0.05)

Further comparison | Manual analysis of 200 random RSO observations

- **E1** Part of the group is hidden by trees/vegetation
- **E2** Suspected counting error of RSO
- **E3** The group is partially or totally out-of-strip
- **E4** Missed by the semi-auto DL model
- **E5** The group was not found on concurrent images



Population estimates (Jolly II analysis)

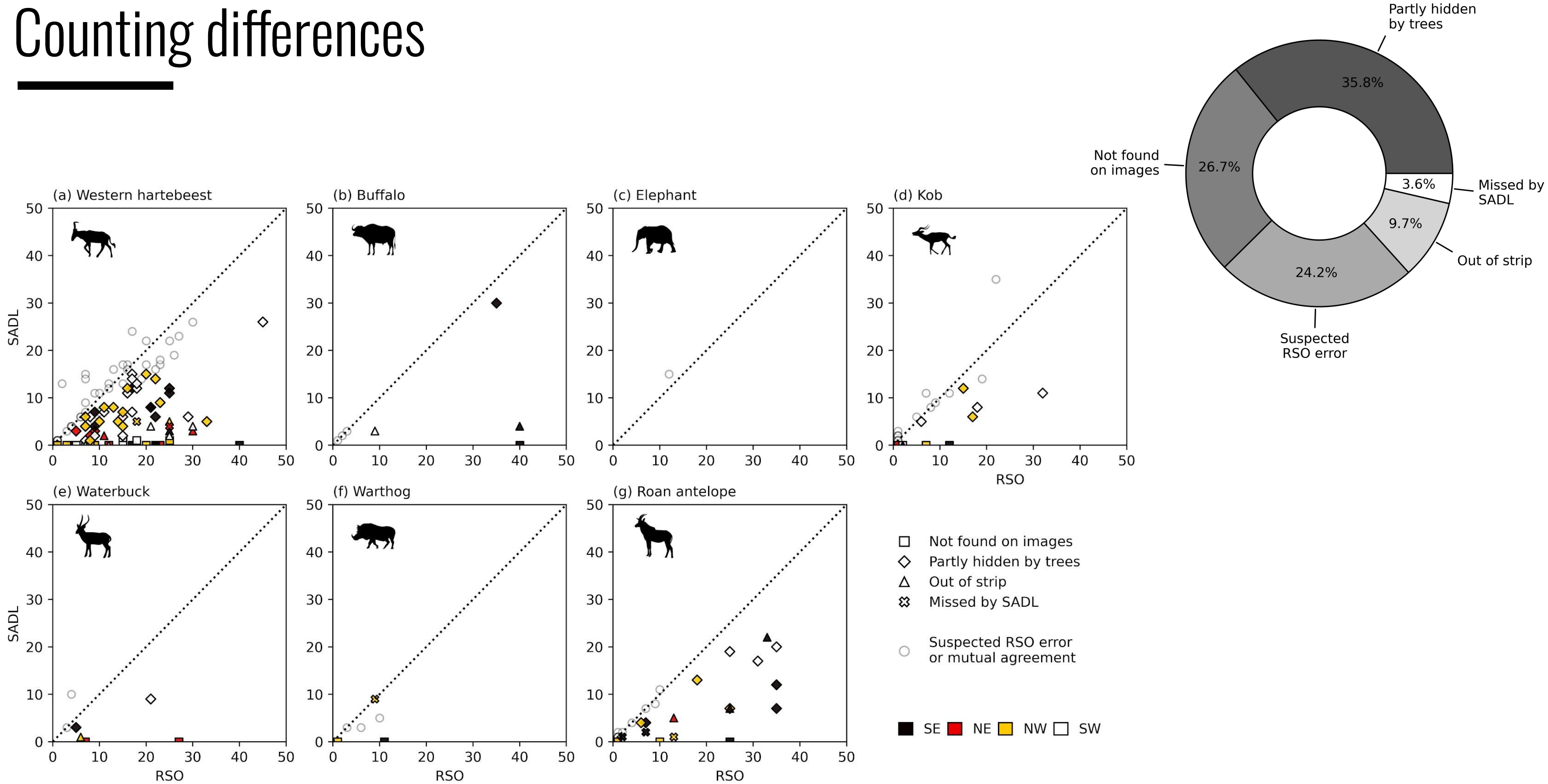


Species silhouettes were sourced from https://www.phylopic.org/. The western hartebeest and waterbuck silhouettes are from Jan A. Venter, Herbert H. T. Prins, David A. Balfour & Rob Slotow (vectorized by T. Michael Keesey), available under the CC-BY 3.0 license (https://creativecommons.org/licenses/by/3.0/), all other silhouettes have been dedicated to the public domain.

Population estimates (Jolly II analysis)

	NW		NE		SW		SE		Total				SADL-OCC vs RSO			
Species	$\hat{Y}_S$ (SE)	$\hat{Y}_R$ (SE)	$\hat{Y}_S$ (SE)	$\hat{Y}_R$ (SE)	$\hat{Y}_S$ (SE)	$\hat{Y}_R$ (SE)	$\hat{Y}_S$ (SE)	$\hat{Y}_R$ (SE)	$\hat{Y}_S$ (SE)	$CI_{95\%}$	$\hat{Y}_R$ (SE)	$CI_{95\%}$	t	p	level	Δ%
Western hartebeest	5243 (713)	4972 (869)	2287 (274)	2630 (428)	7716 (546)	7424 (901)	2316 (356)	3793 (621)	17562 (1005)	± 11%	18819 (1461)	± 15%	-0.709	0.479	ns	-7%
Buffalo	425 (200)	220 (105)	9 (6)	9 (6)	2669 (754)	1852 (710)	284 (190)	813 (476)	3387 (803)	± 46%	2894 (861)	± 58%	0.419	0.676	ns	17%
Kob	1743 (381)	520 (187)	454 (126)	213 (107)	7766 (799)	2102 (425)	181 (54)	142 (70)	10143 (896)	± 17%	2977 (482)	± 32%	7.045	<0.001	***	241%
Waterbuck	249 (77)	73 (44)	250 (76)	694 (261)	893 (160)	275 (123)	168 (66)	542 (176)	1559 (204)	± 26%	1585 (341)	± 42%	-0.064	0.949	ns	-2%
Elephant	0 (0)	0 (0)	0 (0)	0 (0)	275 (133)	225 (109)	0 (0)	0 (0)	275 (133)	± 95%	225 (109)	± 95%	0.290	0.772	ns	22%
Roan antelope	930 (255)	820 (239)	500 (88)	833 (236)	1560 (210)	1535 (300)	755 (210)	1432 (404)	3745 (401)	± 21%	4621 (605)	± 26%	-1.206	0.230	ns	-19%
Warthog	849 (158)	278 (99)	111 (29)	46 (30)	1785 (209)	584 (125)	200 (71)	213 (97)	2946 (273)	± 18%	1121 (189)	± 33%	5.498	<0.001	***	163%

Counting differences



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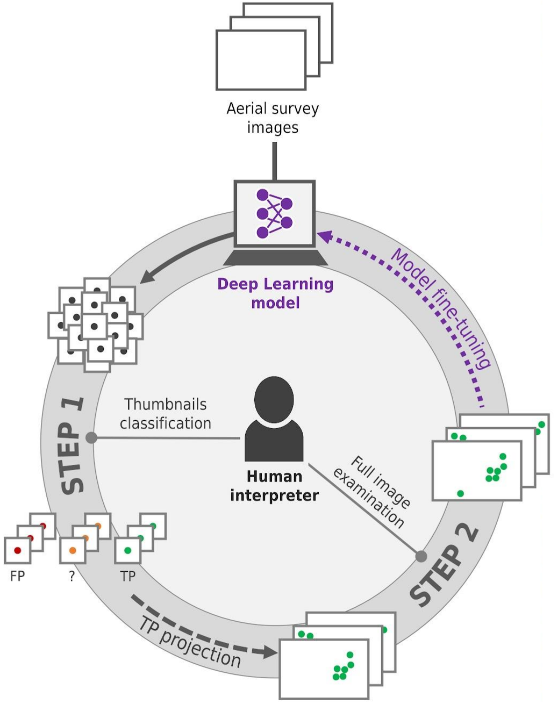
Human effort

Total human investment | 111 hours, i.e. around 14 working days, for **1 human**

Machine run | 530 hours, inference and fine-tuning combined

	Number of images		Allocated time	
Human task	**First pass**	**Final pass**	**Total (relative share)**	**8h-workday equivalent**
Thumbnails classification	85,779	93,472	24.0 hours (33%)	4.7 days
Full 24MP image examination	3,188	529	64.3 hours (58%)	8.0 days
Duplicate removal	1,739	163	9.5 hours (10%)	1.1 days



Full human interpretation | 5000 to 6000 hours for the ~150k images (assum. 2.0 to 2.5 min/image)

↳ Semi-auto DL model = **98% of time saving** (1-111/5000)

Observers flight time | ~160 hours, RSOs and FSO cumulated (3 x 54h)

↳ Model detection checking is a **faster** task than on-sight counting

Conclusion

RSOs: on-sight count → **OCC: photo count** → **AI: detection check**

Hard task, often **biased** by **human**, survey and environmental factors

Image interpretation, more **reliable counts** but **expensive** and **slow**

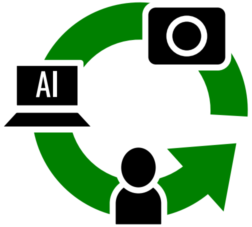
Automated image processing, **reliable?** **Less expensive, faster?**

Q1 Does a semi-automated approach requiring minimal human effort detect more animals than observers?

- Yes for some species (kob and warthog)
- Not significant difference for the others BUT vegetation cover highly influenced the OCC approach
- The semi-auto model performance had a negligible negative impact on counting results

Q2 Do the results of such an approach improve population estimates?

- Particularly true for kob and warthog
- Tighter CI for all species



Reliable
Faster
Less expensive

98% time saving (manual OCC)

Less tiring work

Need no extra time

Perspectives

How to improve the approach?

- Train on a larger and heterogeneous dataset, with various landscape, species, cameras, etc.
- Combine a second DL model for thumbnail classification?
- Train the model on other classes (e.g. illegal human activities, artisanal gold-mining, livestock)

Thank you for your time, any questions?

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