Monitoring of reintroduced rare plants using UAV data

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Problem statement

Research goal :

To provide a method for reintroduced rare plants monitoring using UAV data.

Advantages of UAV data:

- Low human labor for monitoring territories with complex relief
- Low anthropogenic impact during data acquisition
- Simple data acquisition process
- Cloudless
- High resolution

Subject of Research

- Reintroduced in natural environment Paeonia Tenuifolia
- Artificial Habitat – Botanical Garden
- Natural Habitat – protected area

Proposed method

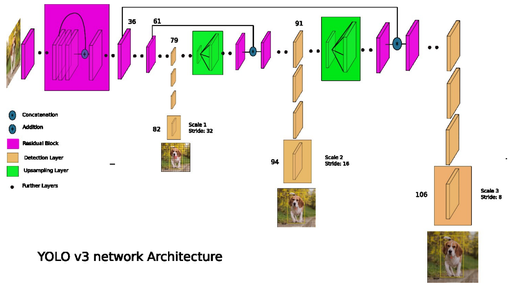
Input data:
- RGB image obtained by UAV during flowering period

Output data:
- Bounding boxes of flowers in the image
- Number of flowers in the image

Proposed Method:

1) UAV image capture of Paeonia Tenuifolia in an artificial environment in the Botanical Garden during the flowering period;
2) collecting UAV data of reintroduced plants in the natural environment during the flowering period;
3) training the object detection neural network using the images obtained in Botanical Garden and transfer learning approach;
4) classification of the images obtained in the natural environment and computation of the target plant amount.

Object Detection Network:
- YOLO v3 pretrained using MSCOCO 2017 dataset
- Implementation [1]
- Network architecture figure [2]



YOLO v3 network Architecture

[1] Wang, C. Y., Bochkovskiy, A., & Liao, H. Y. M. (2021). Scaled-yolov4: Scaling cross stage partial network. In Proceedings of the IEEE/cvf conference on computer vision and pattern recognition (pp. 13029-13038)
[2] Katuria, A. What's new in YOLO v3? [Electronic resource] – URL: https://towardsdatascience.com/yolo-v3-object-detection-53fb7d3bfe6b

Flight Campaign and Fieldwork

Artificial habitat: Botanical Garden (53°12'52.25"N, 50°10'18.6"E)

Natural habitat: protected area of regional significance called "Chubovskaya steppe", village Chubovka, Kinelsky district of the Samara region

Flight Campaigns	#1	#2
Weather	sunny and windless	sunny and windless
Coverage, square meters	8000	6200
Sight	natural habitat	Botanical Garden
Date	23-05-2022	18-05-2022
Relief	slope	flat

Device:
- DJI Phantom 4 PRO v2
- RGB camera

Flight Characteristics:
- 10 meters above the ground
- 80% intersection in the longitudinal and transverse directions relative to the route
- equivalent spatial resolution is 0.01 meters

UAV data processing

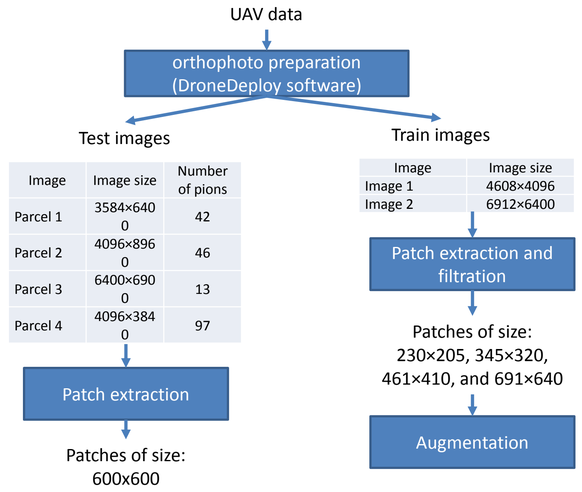


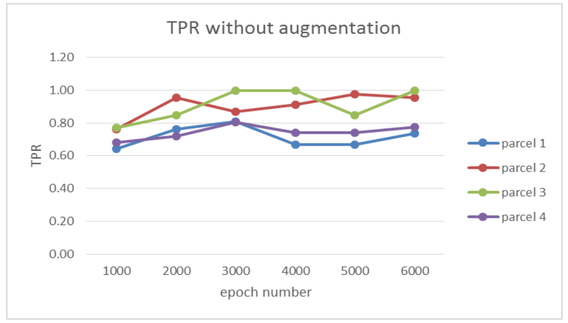
Image	Image size	Number of pions
Parcel 1	3584×6400	42
Parcel 2	4096×8960	46
Parcel 3	6400×6900	13
Parcel 4	4096×3840	97

Image	Image size
Image 1	4608×4096
Image 2	6912×6400

Augmentation type	Algorithm	Patch number
Simple	***Flip:*** Horizontal and vertical, ***90º Rotate:*** clockwise, counter-clockwise, upside down	228
Geometry	***Simple augmentation*** ***Scale and Crop****:* min zoom 0%, max zoom 30% ***Rotation:*** between -20º and 20º	434
Geometry + Brightness	***Geometry augmentation*** ***Saturation****:* between -28% and 28% ***Brightness:*** between -30% and 30% ***Exposure:*** between -14% and 14% ***Blur:*** up to 1 pixel	1019

Experimental evaluation

Epoch number selection: best average TPR – 0.87 for 3000 epochs



$$TPR = \frac{N_1}{N}, \quad FPR = \frac{N_2}{N},$$

N_1 - correctly detected flower number,
N_2 - incorrectly detected flower number
N - true number of pions in the image

Augmentation and epoch number selection:

Augmentation type	Epoch Number 3000		Epoch Number 4000	
	Average TPR	Average FPR	Average TPR	Average FPR
Simple	0.84	0	0.84	0
Geometry	0.86	0	1	0.34
Geometry + Brightness	***0.92***	***0.01***	***0.93***	***0.005***

Detailed accuracy for best augmentation and epoch number:

Image	TPR	FPR
Parcel 1	0.74	0.00
Parcel 2	1.00	0.02
Parcel 3	1.00	0.00
Parcel 4	0.98	0.00

Conclusion

This study establishes a method of rare plant monitoring using UAV data and the YOLOv3 neural network. The proposed method provides an automatic mapping of reintroduced pion flowers in their natural habitat and the automatic assessment of flower population size. With the help of UAV data, we offer a cheap, ecological, and human-labor-keeping flower monitoring technology.
The best average detection accuracy is 93% for correct detection and 0.5% for false detection. The key aspect of the proposed method is to train the network using only images of plants growing in artificial habitats. To meet our needs we used a transfer learning approach and data augmentation.
In our study, we identified the optimal parameters of the neural network augmentation and epoch number. The best results were achieved using geometrical and brightness types of augmentation and 4000 epochs for training.
Our main findings are:
1) images captured in artificial habitats can be successfully used for network training without additional images made in natural habitats.
2) the interpolation of images during training reduces the detection performance;
3) the brightness augmentation is more valuable than the geometric one in this particular task.

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