Monitoring of Reforestation Projects

Design Project

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Introduction

Source: onamission.world

Objective

Establish an all-round method to **monitor reforestation projects**...

- ...applicable to different circumstances.
- ...usable with different data sources.

The project report was presenting the method using **satellite** images of the area of interest for the external partner.
This presentation focuses on **unmanned airborn vehicles (UAVs)** images created for the project.

Data Source

UAV

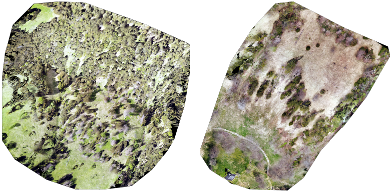


Table: UAV data details

Drone	Mavic Air
GSD	3[cm]
Location	Les Voëttes(VD)

SATELLITE

Table: Satellite data details

Sensor	WV-4
Resolution	30[cm]
Location	Sindhupalchowk(NPL)

UAV Data acquisition I

Flight planning for UAVs' missions is necessary to create useful data sets. **Pix4D Mapper** software was used and provides post-processing tools for generation of mosaic orthophoto, point clouds, DSM, DTM, etc.
Efforts focus on optimizing two main resulting characteristics:

Ground Sampling Distance (GSD)
Resulting resolution on ground is a function of camera parameters.

Overlap
The quality of the resulting orthophoto and 3D model (structure from motion) is a function of the overlap.
The pose (X,Y,Z, pitch, yawl, roll) of the sensor at each take (image view) is also required for good reconstitution. A gimbal insures the nadir view at all time, cancelling with some precision[1]the actual pose of the platform.

[1]Not provided for this type of low-cost drones.

UAV Data acquisition II

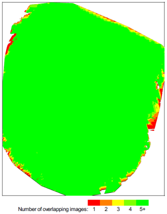
Table: GSD: used hardware

Platform	DJI Mavic Air
Sensor	1/2.3" CMOS (12MP)
Best single shot interval	2 [sec]

Source: toppng.com

Table: Overlap: used parameters

Side overlap	0.6
Front overlap	0.4
View mode	Nadir



Source: Pix4D qualtity report

Single Tree Detection [1],[2],[3],[4]

Used tool: Detect object using Deep Machine Learning from ArcGIS Pro.

Sample: sufficient amount of manually identified trees on the image that feeds the neuronal network.

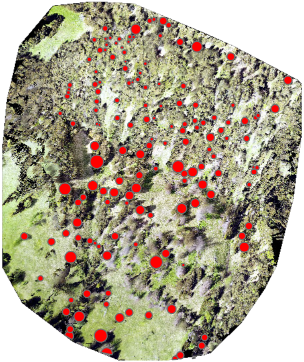
Train: based on the PyTorch deep learning framework using the fast Single Shot Detector model. It uses the *ResNet34* as pre-configured model.

Detect: some parameters are adjusted to filter the model interpretation: confidence threshold and overlap ratio.

Accuracy: assessment points randomly generated over ground truth manually created data are updated over the results of detected objects. The main parameters are the number of points generated and the number of classified objects on the ground truth layer. The number of assessment points can't be greater than the number of classified objects.

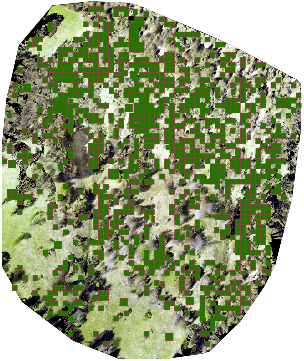
Results: **Single Tree Detection**

Sample



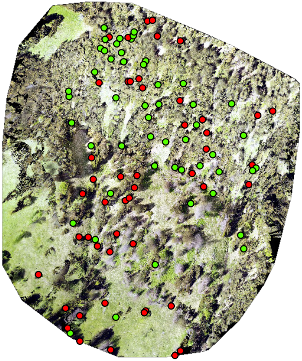
Samples	ca. 200
Image chips	ca. 4000

Detection



Trees detected	1003
Threshold	0.98
Overlap ratio	0.1

Accuracy



Accuracy	51%
Assess. points	100
Distribution	random

Accuracy: green is successful classification, red is unsuccessful classification (not found trees)

Satellite image preparation: **Pansharpening** [5]

Panchromatic (450–800 nm) sensors band obtain the best resolution. Coupling multispectral bands to the panchromatic one is a process known as *Pansharpening*. It yields a **colored imaged at the panchromatic resolution**. Several methods exist. The most common is Gramm-Schmidt's:
It uses information from all 5 bands (Pan,R,G,B,IR) by **orthogonolizing** each band's vector. The algorithm attributes a weight to each band depending on the sensor properties.

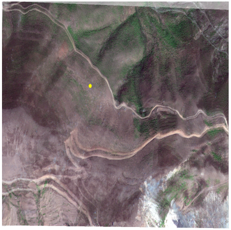
Table: Pansharpening: used parameters

Sensor	WV-4
Weights(R,G,B,IR)	0.38,0.25,0.2,0.16

Satellite image preparation: **Georeferencing**

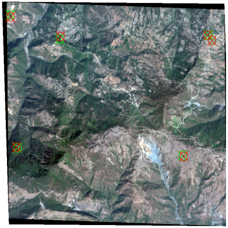
Two methods of georeferencing were tested:

Superposing images and shifting one with respect to the other. Less reproducible but more user friendly.



Area of interest, 03.03.2018

Standard georeferencing using coordinates of 6 control points. Very reproducible but may induce distortion.



Full image, 03.03.2018

The image preparation is limited due to geometric deformation, the use of different sensors, nadir angles, etc.

Satellite: Normalized Difference Vegetation Index [6]

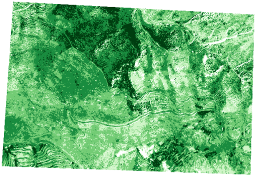
NDVI provides with additional information for reforestation monitoring by computing biomass and leaf area index. The change detection strongly depends on the accuracy of the georeferencing.

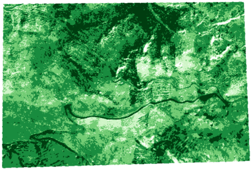
Data must provide with red and infrared bands:

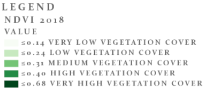
$$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R}$$

Satellite results: **NDVI**

Value





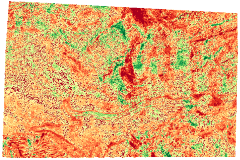


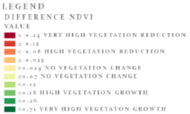
Recent Epoch: 16.03.2018

Minus

Old Epoch: 03.03.2018

Difference





Discussion: **Data Acquisition**

Data acquisition is an important step which predefines the potential results quality.

Nowadays, with use of high-end **UAVs** (drones) very satisfactory results can be obtained with little background knowledge. Post-processing software as Pix4D Mapper make this step very accessible.

Satellite imagery acquisition demands more specific skills. Specific parameters have to be chosen carefully (nadir angle, resolution, bands, etc.). Although some platforms try to make the acquisition more user friendly, the high number of different image types and providers makes the choice still complicated. Also very high resolution imagery still comes at a non-negligible price.

Data acquisition: SWOT analysis

Data source	**UAV**	**SATELLITE**
Strength	Temporal/Spatial resolution are selectable	Data acquisition is independent
Weakness	Flying length is drone battery dependent	Spatial resolution is limited
Opportunities	More precise Single Tree Detection	NDVI computation possible
Threats	Data acquisition is time consuming	Georeferencing and data availability

Discussion: **Method**

The method adapts well to different data sources. The important difference in resolution between UAVs and satellite images greatly impacts the amount of information (pixels) for each objects (trees). Steps of the method can be adapted accordingly:

- **Sampling**: for a same result less samples are needed with higher resolution. This step becomes less time consuming.
- **Confidence threshold**: can be increased greatly. In this project, the used values are: 0.05 for satellite images, 0.98 for UAVs images.

The **accuracy assessment** quality highly depends on the statistics. The more assessment points the better. To compare works, same number of assessment points must be used. Also independent ground truth data would improve this assessment quality.

Method overall SWOT analysis

Strength	All-Round Method, NDVI and Single Tree Change Detection
Weakness	Strong dependence on training data
Opportunities	Possibility to publish results on a ArcGIS Online for direct use.
Threats	Insufficient georeferencing precision

Conclusion

This project includes:

- Not very complex content, but multiple isolated specific steps which must be carefully conducted.
- Results are promising but more experience is needed.
- Adaptation to each case is still necessary.

Further work should focus on:

- Creating a large various sample data set and test the model on different types of site.
- Satellite data acquisition and preprocessing for geometric deformation.
- Creating a manual for standard UAVs data acquisition (will be delivered to the external partner).

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