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Monitoring rangeland biomass during wet and dry seasons from a video obtained with a simple digital camera

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Abstract

Photogrammetry is an image analysis that produces a 3D model of on object using a set of images taken from different positions. We tested this technique using a digital camera to produce a 3D model of 1m^2 of Sahelian rangeland grass. In 2019 we made measurements on 3 squares of 1m^2 (images capture and biomass measurement) in each of 10 days in the wet season and each month during the dry season. We analysed the images using PIX4D software. We extracted the volume and the colour indexes from the pix4D output. We used a random forest to predict the dry and fresh mass of the grass. The percentage of variance was 46.31% for the fresh mass and 40.46 % for the fresh mass. This tool could be used to monitor grass biomass during both wet and dry seasons and implemented in a grass observatory.

Keywords: structure from motion, Sahel, PIX4D, 3D model

Introduction

Photogrammetry is a generic term that regroups all analyses where photography is used to make measurements. One of these analyses is called “Structure from motion.” (Frey *et al*., 2018). The concept of the analysis is that the structure (3D model) of an object is recreated from a set of images taken from different angles. The structure of motion is widely used on UAV images to create an orthomosaic and digital surface model of an ecosystem. Structure from motion can also be used from the ground with a digital camera. Previous work shows that 3D models obtained from digital cameras were linked with the mass of the herbaceous layer (Bossoukpe *et al.*, 2020). This work was carried out only at the end of the growing season (end of the wet season). The goal of the study reported here was to test the utilization of this approach to monitor the biomass during both the growing season and the dry season.

Materials and methods

At the Dahra Research Station in northern Senegal, we made measurements on a natural rangeland in an enclosure during the wet season. The measurement started on 27 August 2019 (30 days after the first rain event of the 2019 wet season) and was made every 10th day until the end of the rainy season (here the 5 November). Measurements were made every month during the dry season to evaluate the quantity of straw material until 4 February 2020. For some videos the 3D model could not be made. 17 models were available for the wet season and 18 models for the dry season.

At each measurement, 3 squares of 1m x 1m of grass were sampled using a Camera Campark 20 with the camera in video mode. The video was taken horizontally at 1 m above the ground, oriented to the ground, taken along fives lines. We used video mode in preference to static images because it is easier to take one movie than taking 300 images of the squares. The video was in 1980*1080 resolution. We took between 350-400 images from this video.

The grass was cut and weighed to obtain the fresh mass, and samples were dried and weighed to obtain the dry mass. The video was analysed using the PiX4D software. The outputs of the PiX4D software were an orthomosaic and digital surface model. The project was scale with the square and a height reference. We extracted the colour from the orthomosaic and height from the DSM. From the three colours we calculated several indices (Table 1).

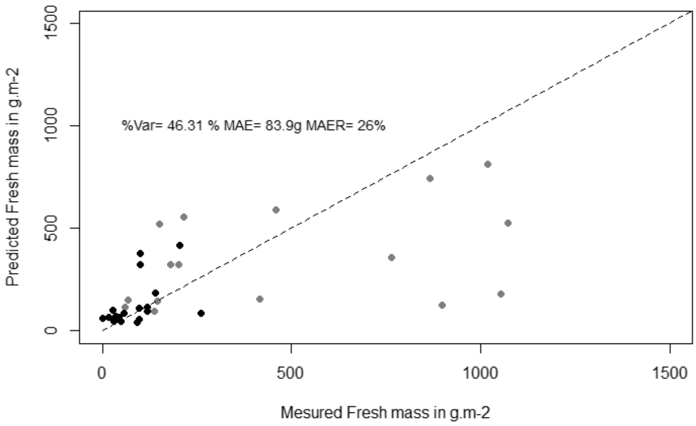
Table 1. List of the Vegetation indices used (R: red, G: green and B: Blue).

Acronym	Formula
NDGRI	(R-G)/(R+G)
NDBRI	(B-R)/(B+R)
NDBGI	(B-G)/(B+G)
Vari	(G-R)/(G+R-B)
Exg	G-0.39*R-0.61*B
GLI	(2*G-R-B)/(2*G+R+B)

These indices were combined with the maximum and mean height obtained from the DSM. We used a random forest algorithm (package randomForest for R software) to predict the fresh and dry mass. Due to the unbalanced data of the masses, we used a square transformation and afterwards we analysed the residuals of the random forest between the different dates.

Results and discussion

The random forest for the fresh mass explained 46.31% of its variability (44.41% for the dry mass). For both, the most important variable was the mean height obtained from the DSM; thus the NDGRI index (and the VARI indexes for fresh mass). This means that both colour and 3D variables can be used to evaluated the grass biomass. This results concord with work using UAV where both types of variable are important.



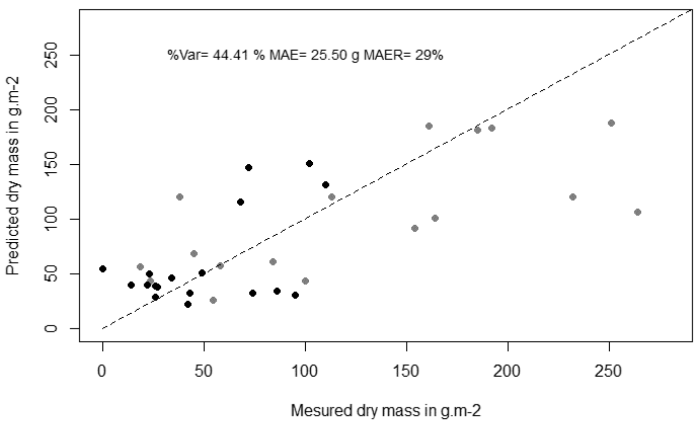


Figure 1. Predicted biomass obtained for the random forest versus measured biomass for the fresh mass and the dry mass. The black dots are the data in the dry season and the grey for the wet season, with the median absolute error (MAE) in g and the relative median absolute error (MAER) in %.

The residuals were different between the different dates of measurement. The random forest underestimates the mass at the end of the season but overestimates the mass at the beginning of the season. The same random forest model cannot therefore be used during the whole year. More data will be required to be able to build models for different times during the year.

Conclusions

This work shows that some parts of the variability of the biomass of natural rangelands can be captured using a simple camera and the "structure of motion" process. This kind of process could be used to develop a participatory observatory of rangeland biomass growth based on a network of observers using cameras.

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