Ground based photogrammetry to assess herbaceous biomass in Sahelian rangelands

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Abstract
This study conducted in a pastureland in Senegal aims to evaluate the herbaceous biomass from ground-based photogrammetry. Photogrammetry is an image analysis that use a set of images of an object to create a 3D model of this object. The technic used the parallaxes obtained from images taken from different points of views. We used the photogrammetry with a low cost RGB camera to predict herbaceous biomasses. We made a set of images taken with different positions of 1m² of grass on 35 plots of pastureland. The images were processed using Pix4D software. Herbaceous volume were assessed using canopy height model. Red, Green and Blue reflectance's were obtained from the orthomosaics." We calculated normalized difference index for each combination of colours. We measured fresh and dry herbaceous biomass on the field the same day of image capturing. To test the reliability of our methods for assessing biomass, a PLS analysis between field measurements and variables obtained from the camera was performed. Around 60% of the variability of herbaceous biomass were explained by camera variables especially the volume from photogrammetry and the red reflectance. This work showed that a low cost camera could serve as useful tool for estimation of biomass.

Introduction.

Sahelian rangelands are the main source of feed for the pastoral livestock activity. The vegetation of Sahelian rangeland is composed of two types of plant communities; annual grasses and sparse trees communities. Even if both communities are eaten by livestock, annual grasses represents the main part of their feed. Furthermore, annual grasses are strongly related to the annual variability climate. Evaluating the available grass quantity in this region is a key aspect for the management of livestock pastoralism system.
Many studies used remote sensing to upscale annual grass production at a wilder scale, but this upscaling require field biomass measurements. Field biomass measurement are quite undertaking work. It may require some specific knowledge on botanic for example.
The possibility of indirect measurement of grass characteristic is a hot topic for grassland scientist. One of the working group of the European grassland federation is on" sensing". One of the novelty is grassland sensing is the use of UAV. One interest of the UAV is to produce 3D model using photogrammetry(Lussem et al. 2019). Photogrammetry is an image analysis that can recreate an object in 3D using a series of image taken from different point of views. UAV can so estimate the grass volume (Possoch et al. 2016). Photogrammetry can also be used with classical camera. In this study, we tested the use of photogrammetry based on field camera images to assess the biomass of Sahelian rangeland.

Materials and Methods
Our study sites were in the ISRA (institut sénégalais de recherches agricoles) Zootechnical Center of Dahra Djoloff. (Latitude 15 .349,

Longitude -15.445) in Northern Senegal. The center is a research station with an area of almost 7000 ha included natural Sahelian rangeland.
We selected 36 plots around the center. On each plot in October 2018, we choose one squared meter of natural grass communities using a metal square quadrats. Around our quadrat, we cut around 10 cm the grass surrounding the quadrat to have bare soil around our measure square. We also put similar object (here a box) as a height referential close to all the squares. We used a Canon Ixus 180. We made a video capitation of the grass vertically to the ground at around one m from the ground. We follow a grid of 5 lines to cover all the square with the camera. After, the video capitation we cut all the grass within the square. We weighted it to obtain fresh mass. The sample were dry to obtain dry mass and so the dry matter content.
The video obtained was analyse using the PIX4D software. The video was cut in different images (around 300 images). The 300 images are after used in the 3D mapping process. In the 3D mapping processing, the first step is to identity some key points that present on several images. Thus, triangulation is made to evaluate the position of the key point. Thus, a densification process is made by interpolation of the different positions of the key points and so produce a 3D model of the object. We used the square and the box to set the referential of the 3D model. An example of 3D model obtained are presented in figure 1.
We extracted for the 3D model the surface model and the orthophotography. We also used pix4D to produce a terrain model. For each plot, we extracted the volume of grass from the difference between surface model and terrain model. The Terrain model was automatically obtain from the Pix4D software. We also extracted the red, blue and green value. We calculated the normalised difference index between two colours (NGRDI Normalized green red difference index; NRBDI Normalised red blue difference index, NGBDI Normalized green blue difference index).
We made a Partial least squared regression between the different variables obtain from the video (volume, three colours and three normalised difference index).

Results and Discussion

The figure 2 show the correlation circle obtain for the PLS. The R^2 for the Y of the PLS was of 0.55. The Q^2 of the two dimension were of 0.58 for Fresh Mass, 0.60 for the Dry mass and 0.10 for the Dry mass content. The DM and FM were positively correlated with the volume and the difference between green and Red and negatively with the red colors. This work is a first work that show that the interest of photogrammetry from simple camera to assessed some characteristic of the vegetation. In our test, the state and the composition of the vegetation was quite similar, more work are required to be done to increase the variability of the situation tested. Similar technic could be done with camera with more color bands especially in the infrared. It could improve. Another perspective is to use this technic on video obtain from a participative observatory. People could take video with smartphone and send it to a server that could make grass biomass prediction.

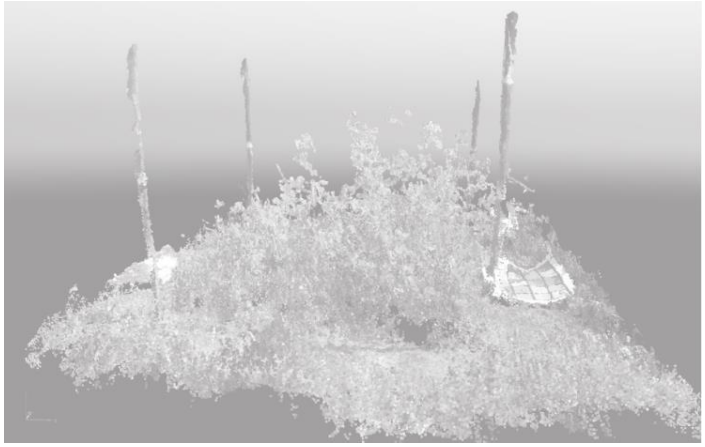

Figure 1Example of 3D model of a Sahelian grass square obtain from PIX4D

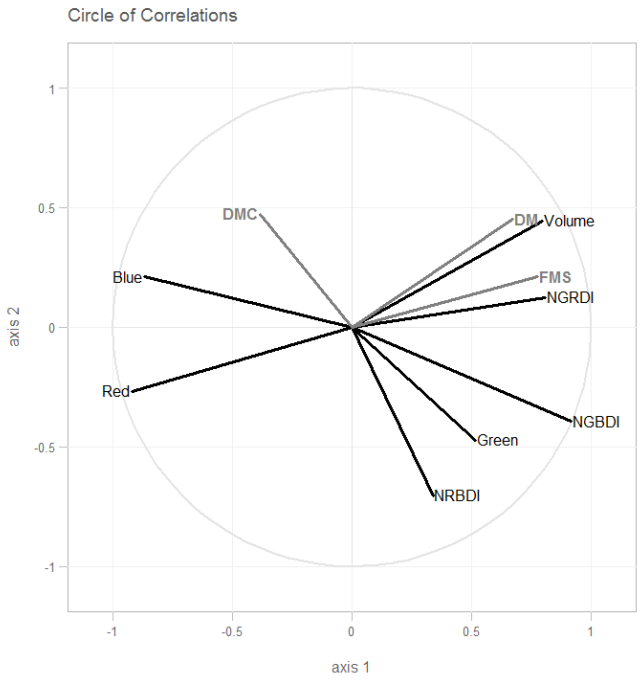

Figure 2: Circle of correlation from the PLS. X variable Volume, colours canal and Normalized difference indexes. Y variables Fresh Mass (FM), Dry Mass (DM) and Dry matter content (DMC). The two axis are represented of the two first components of the PLS.

Reference

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