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Estimation of biophysical parameters to monitor and manage pasture using a mobile application

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***Abstract*— *This study aimed to develop a mobile solution for the estimation cover of green vegetation, pasture height, and aboveground biomass of pasture using orthogonal images. Experimental plots of Panicum sp grass were photographed in two experiments. The first experiment yielded data on plot biomass and the second experiment on pasture height. All samples were automatically georeferenced using the GPS location function of the smartphone. For green cover area, the application uses a region-growing segmentation algorithm and conversion to HSV color space (Hue, Saturation and Value) to obtain the relation of the regions where pixels average in the green matrix and compare the number of pixels classified as pasture with the total number of pixels in the image. The method for estimating height and biomass divides into two parts. The first part is the extraction of characteristics from the images using texture parameters, vegetation indexes, and information about image shadow projections. In the second part, a regression model was developed using the SVR (Support Vector Regression) technique. The model provided accuracy of 0.518 and 0.647 for the estimates biomass and pasture height, respectively.*

***Keywords*— Mobile Application, Pasture, SVR, Computer Vision.**

I. INTRODUCTION

Recent advances in agricultural technologies have increased the efficiency of daily farming operations such as planting, fertilizing, and harvesting and reduced input waste. The apparatus of geolocation technology and field precision devices in the field has enabled greater resource efficiency, thus contributing to greater savings, intelligence and sustainability. However, large scale surveys of pasture biophysical parameters is still a challenge in the sector by reason of the high cost of equipment needed to measure aspects related to plant characteristics or phenotypes, which can be explored by remote sensing. This search, according to SANTOS and YASSITEPE [1], is known by the scientific community as phenotyping bottleneck because of the gap between the quantity and quality of available genomic and phenotypic data.

Information technology has gained wide application in livestock industry, being its main driving force the search for more efficient production. The techniques that use computer vision and image processing are essential for the advancement of phenotyping technology [2].

Smartphones can integrate image capture and processing technologies, which has allowed computer vision applications. In addition, it is possible to find the geolocation of the images through the devices, store, and process the data. Mobile devices have great affordability and wide diffusion in the agricultural sector, thus, they could be a potential aid tool for extracting phenotypic information from pastures.

In this context, we propose the Capta Pasto© application as a solution to estimate a number of biophysical parameters using pasture images. The current version of the application was implemented to estimate the

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following parameters: green cover; pasture height, and aboveground biomass. Given the above, the present study aimed to develop a mobile application to estimate biophysical parameters applied to the monitoring and management of pastures (*Panicum* sp.).

II. MATERIAL AND METHODS

The Android Studio 4.2 integrated development environment was used to implement the application. The algorithm was developed using Java, XML (eXtensible Markup Language) for application interface features and SQLite for database. The current Capta Pasto© version allows the estimation of the biophysical parameters green cover, pasture height, and aboveground plant biomass.

To estimate green cover, we developed an algorithm using the computer vision region-growing segmentation technique. In the first stage, the algorithm groups the neighboring pixels with similar properties, then, using the average HSV color space (hue, saturation, and value) of the regions captured in the image, it identifies the pasture and non-pasture classes. The green cover area is estimated based on the number of pixels identified as grazing class and the total number of pixels in the image (Figure 1).

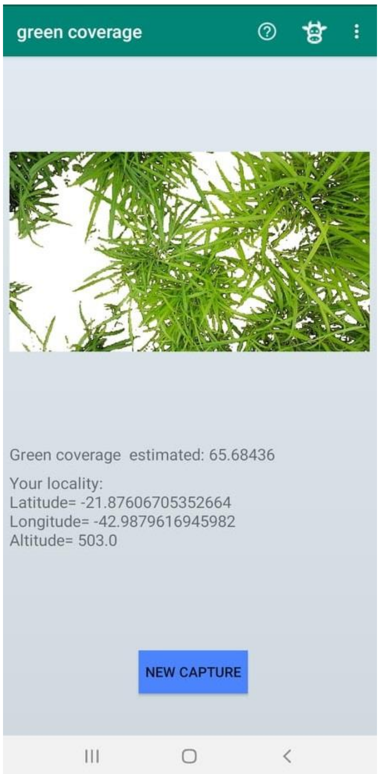

Fig.1: Visual image the estimation module of the green cover estimated.

Using computer vision techniques, we extracted the information from the images. First, it was implemented the image capture routine and calculation of the following vegetation indices: Modified a Photochemical Reflectance Index - MPRI [3]; Triangular Greenness Index - TGI [4]; Green Leaf Index - GLI [5], and the Visible Atmospherically Resistant Index - VARI [6].

$$MPRI = \frac{(G-R)}{(G+R)}$$

$$TGI = G-(0{,}39\times R)-(0{,}61\times B)$$

$$GLI = \frac{(2\times G-R-B)}{(2\times G+R+B)}$$

$$VARI = \frac{(G-R)}{(G+R-B)}$$

Where R is the image data of the red region of the light spectrum; G is the image data of the green region of the light spectrum; and B is the image data that are captured in the blue region of the light spectrum.

Some image texture attributes and information about shadow projections in the images were also extracted. With this information, a model was developed to predict the parameters of interest for the research carried out. Thus, an algorithm was implemented in the Jupyter Notebook development environment using the Support Vector Regression (SVR) computational intelligence technique in the Python programming language.

Support Vector Regression is based on a Support Vector Machine (SVM) [7], which is a machine based on supervised statistical learning. In view of the good results in research using this technique, we propose a model to predict pasture height and aboveground biomass.

For each new image captured, the application obtains the coordinates along with the selected parameter using the smartphone's GPS location function. Then, all this data is stored in the database. Figure 2 exemplifies a biomass capture by the application and Figure 3 an estimate of vegetation height.

Biomass data was extracted from 3 photographs taken with 3 different mobile devices in 30 randomly-chosen plots, totaling 90 photographs. All photographs were taken at an angle perpendicular to the canopy between 1.0 m and 1.4 m above ground. The optical images of the vegetation are from an experimental area of Embrapa Dairy Farming, municipality of Coronel Pacheco, MG, taken in February 2020, during the summer season, a period when the vegetation usually shows greater vigor.

Figure 4 shows examples of pasture photographs from the experimental plots of *Panicum* sp. grass. Samples were taken from all plots photographed in an area of 0.5 m². Afterwards, the fresh weight of samples was determined and dry matter was weighed after oven drying. Then, the data of each plot was converted to kilograms per hectare (kg/ha).

Pasture height data was extracted from photographs taken with a mobile device, following the same methodological procedure used for the photographs to estimate biomass. Pasture optical images were made in 32 plots located in the municipality of Mar de Espanha, MG, in July 2020. Height of all samples photographed was measured with a metric ruler, and Pearson's Correlation coefficient sand cross-validation accuracy were estimated.

Fig.2: Visual image of the estimated biomass.

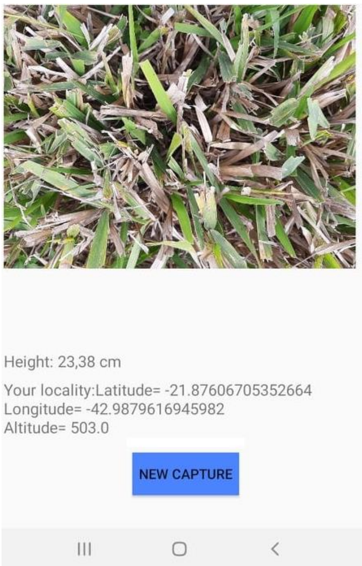

Fig.3: Visual image of the estimated height.

Fig.4: Example of photograph taken in the field.

III. RESULTS AND DISCUSSION

The application was developed using the free platform of the Android Studio software. This programming system was chosen because, according to data from IDC (International Data Corporation), Android is present in approximately 85% of smartphones [8]. The application was designed to be intuitive and friendly. The routines implemented in the application enabled good results in georeferencing the images, in the extraction of information, and storage in the database. Furthermore, the application interface allowed the user to handle, organize, and view the information generated easily.

Cover of green vegetation is an important indicator of soil degradation and soil cover [9], and is closely related to available biomass and feed conversion necessary for efficiency in animal production systems. In the present study, using the potential regression, we found Pearson's correlation of 0.664 between biomass and green cover, that is, a good indicator of the vegetation status. Figure 5 shows the scattering function and regression.

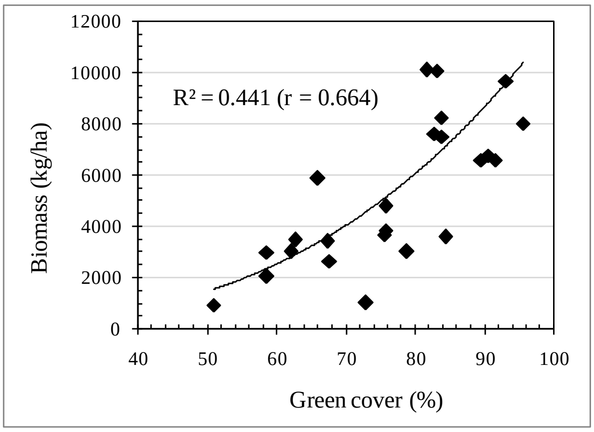

Fig.5: Scatter and regression plot between green cover and aboveground biomass.

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The cross-validation method, with 6 sets, was used to analyze the SVR method of biophysical parameter estimation. Accuracy of biomass and pasture height estimates was 0.518 and 0.647, respectively. Figures 6 and 7 show the values estimated.

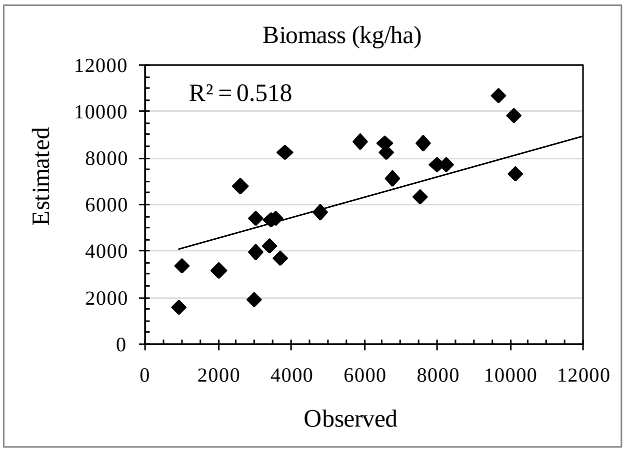

Fig.6: Graph view of the relationship between estimated and observed biomass.

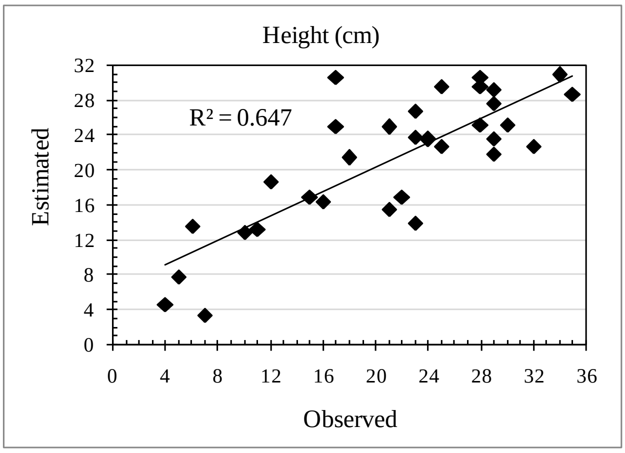

Fig.7: Graph view of the relationship between estimated and observed height.

To further our research we intend to collect more samples at different times of the year, analyze other important parameters for pasture monitoring and management, and calculate the correlation between the parameters and other vegetation indices in the visible spectrum.

IV. CONCLUSION

The application developed enabled users to obtain information about pasture from photographs in the visible spectrum bands using a low cost, highly accessible and easily handling mobile device. The model implemented in the application provided accuracy of 0.518 for biomass and 0.647 for pasture height estimates. In addition, the application allowed data and information of the analyses to be stored, which is promising for pasture monitoring and management, and phenotyping research at various plant growth stages.

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