Precision Livestock Farming '17

Edited by D. Berckmans and A. Keita

Papers presented at the 8th European Conference on Precision Livestock Farming

Nantes, France
12-14 September '17

Differentiating pre- and post-grazing pasture heights using a 3D camera: a prospective approach

A.L.H. Andriamandroso[1,2,4¥*], E. Castro Muñoz[3*], Y. Blaise[2,4], J. Bindelle [1,2], F. Lebeau[4]
[1]*AgricultureIsLife, TERRA teaching and research center, Gembloux Agro-Bio Tech, University of Liège, Passage des Déportés 2, 5030 Gembloux, Belgium*
[2] *Precision Livestock and Nutrition Unit, AgroBioChem, Gembloux Agro-Bio Tech, University of Liège, Passage des Déportés 2, 5030 Gembloux, Belgium*
[3]*Universidad Central del Ecuador, Facultad de Ciencias Agrícolas, Jerónimo Leiton y Av. La Gasca s/n. Ciudadela Universitaria. 170521, Quito, Ecuador.*
[4]*Biosystems Dynamics and Exchanges Unit, Gembloux Agro-Bio Tech, University of Liège, Passage des Déportés 2, 5030 Gembloux, Belgium*
**These authors contributed equally to this publication*
[¥] *naina.andriam@gmail.com, jerome.bindelle@ulg.ac.be*

Abstract

Grasslands management involves the monitoring of both animal and plant components. Recent precision livestock farming developments have focused on high-rate monitoring of grazing animals to enhance livestock productivity and welfare. The evolution of grass resource during the grazing process is not being overlooked by graziers and researchers, but grass characteristics, such as height, dry matter content, productivity or density, are still measured using low frequency and sometimes destructive and time-consuming methods; such as quadrat, sward-sticks, rising plate meters.

This study investigated the potential of using 3D cameras to assess sward physical characteristics. Main objectives were: (1) to define the correct way to capture images, particularly the camera position above the ground and, (2) to assess if differences in sward height were detectable. Couples of images differing in grass height were captured on the same spot with a 3D camera at different above-ground heights (30, 40, 50 cm) on a ryegrass-white clover pasture. Pre-grazing height was 15cm and post-grazing sward was simulated by cutting at 2 cm. Histograms of intensity performed on greyscale images showed differences between pre- and post-grazing sward. As expected, overall darker pixels were observed for pre-grazing images ($p<0.01$) and whiter pixels for post-grazing images ($p<0.01$), indicating longer distances consistent with lower forage biomass. Images taken at a distance of 30 and 40 cm could identify these differences. Further developments require improving the calibration of the camera and developing image analysis method to estimate more plant characteristics such as density or dry matter content.

Keywords: pasture heights, grazing, 3D camera.

Introduction

Feeding animals is a challenge that farmers face in the search of the optimal animal weight gain or milk production and at the lowest cost (Castro et al., 2017). Grasslands constitute the best and cheapest source of feed to ensure milk or meat productions (Boval and Dixon, 2012; O'Mara, 2012). Grasslands characteristics and animal grazing behaviors are in close relationship. For an efficient grazing management the plant-animal interface should be considered at the spatial and the temporal scales on the pasture, besides the monitoring of grazing behaviors (Gregorini et al., 2017). Nevertheless, with regular weighing or daily milking, the monitoring of animals is performed at a higher rate than that of the plant component in the pastoral system. There is a strong need for a better monitoring of the pasture vegetation (Nadimi et al., 2008).

Moreover, on the one hand, since the emergence of precision livestock farming over the past two decades, the monitoring of individuals, using different kinds of sensors, has become more accurate and has offered the possibility to detect behaviors at different scales, from the pasture scale to the finest scale of bites for grazing animals (Gibb, 1996; Carvalho, 2013; Andriamandroso et al., 2016). On the other hand, the different tools used to measure physical characteristics of grass, among which the grass height is the most important, lag still behind in terms of possible application for precision livestock research and farming uses. Measurements of grass height before and after the passage of animals are one method to estimate the intake (Macoon et al., 2003; Smit et al., 2005). Traditionally, pasture height is measured using a sward stick, an electronic capacitance meter or a rising plate meter. The measured height is then used to estimate forage biomass availability via a calibration with cut samples. Calibration errors with these tools average 10% in terms of pasture yields (Sanderson et al., 2001). This technique is mostly used by farmers to have an idea of the importance of biomass that they have on pasture. Recent developments showed that it is possible to automatically monitor the biting pattern of animals (Andriamandroso et al., 2015) and in order to be able to assess simultaneously the intake during the biting process, a rapid method with high temporal and spatial resolution characterizing pasture biomass availability is called for research applications investigating the grazing behavior of animals at the plant-animal interface. Thus, the use of sensors, similarly to what is done with animals, could be one solution to palliate this problem. For example, using a simple digital camera, Bonesmo et al. (2004) developed an image processing system to estimate white clover coverage in a grass–clover mixture, based on clover color and its morphological properties achieving a great correlation with the reality. The seasonal growth status of ryegrass was also detectable using a logistic model on color intensities and indices parameter (Fan et al., 2016). The use of depth cameras in precision agriculture has increased in recent years enabling plant structure characterization and species differentiation (Andújar et al. 2016). In this work, a depth camera was used to assess the difference between grass height before and after a simulated grazing.

Material and Methods

The experiment was carried out in one pasture of Gembloux Agro-Bio Tech (University of Liège, Belgium). An Intel RealSense F200 depth camera (Intel Corporation, Santa Clara, CA, USA) was fixed on a monopod (Figure 1) to take pictures of pasture before (pre-grazing) and after (post-grazing) the simulated passage of the animals done by manual cuts. Three different heights (30 cm, 40 cm, and 50 cm) were tested to define which one was the most suitable for capturing images at the different grass height. The camera objective focused on a 30 × 30 cm² quadrat where the height of the grass was taken with a rising plate meter and a sward stick on 5 random locations within the same quadrat. Five couples of images, corresponding to pre- and post-grazing grass, were taken on five different quadrats.

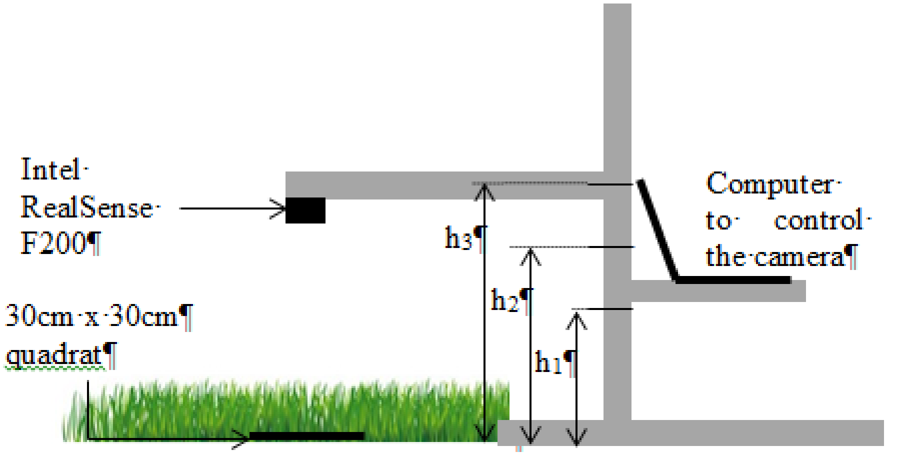


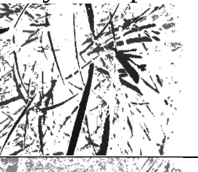
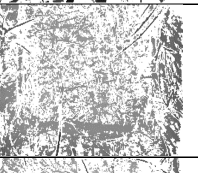
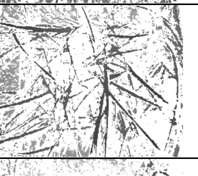
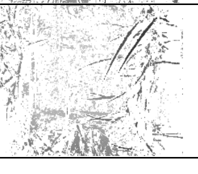
Figure 1: Image acquisition device using an Intel RealSense F200 depth camera, placed at modular heights (h_1: 30 cm, h_2: 40 cm, h_3: 50 cm) on the grass and controllable with a personal computer. A shade tent should be put around the camera to avoid sunlight disturbance.

For the data processing, only greyscale images were taken into account and compared using histogram function of Matlab R2015a (Mathworks, NL). Ten groups of pixel color, named image greyscale intensity class (IGIC, ranging from 0-255) were created to class the different range of pixels of each photo where the group 1 contained the lightest pixels and the group 10 the darkest pixels. The number of pixels present in each of the 10 greyscale groups were then counted and compared on a frequency basis using a general linear model with the GLM procedure in SAS (Cary, North Carolina, USA) with grass height (pre-, post-grazing), height of the camera (30, 40, 50 cm) and their interaction as fixed class variables. The quadrats were used as experimental units.

Results and Discussion

For one sample (sample n°1), pictures taken by the camera are displayed in Table 1 in color and greyscale formats for each camera height and each grazing status. From these tables, it is already possible to see that taking pictures at 50 cm above the ground involved the presence of grasses outside of the quadrat.
Over the ten greyscale intensity classes (IGIC), less differences were shown between pre-grazing and post-grazing grass for images taken at 50 cm (Table 2) confirming the possibility of confusion with grasses outside the quadrat viewed in Table 1.

Table 1: Color and greyscale photos taken by the camera at 30, 40 and 50 cm of heights from the ground and for pre- and post-grazing grass status for sample n°1.

Camera height	Grass status	Colored photo	Greyscale photo
30 cm	Pre-grazing		
	Post-grazing		
40 cm	Pre-grazing		
	Post-grazing		

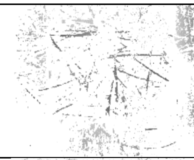
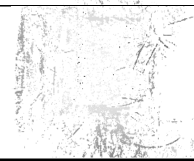
50 cm	Pre-grazing		
	Post-grazing		

Table 2: Comparison of pre-grazing and post-grazing greyscale images taken at 30, 40 and 50 cm above ground considering ten classes of image greyscale intensity class (IGIC) using analysis of variance method.

IGIC	Source	Degree of freedom	p-value
Class 1	Camera height	2	0.308
	Grass status	1	0.358
	Interaction	2	0.589
Class 2	Camera height	2	0.000
	Grass status	1	0.000
	Interaction	2	0.005
Class 3	Camera height	2	0.003
	Grass status	1	0.036
	Interaction	2	0.367
Class 4	Camera height	2	0.019
	Grass status	1	0.752
	Interaction	2	0.019
Class 5	Camera height	2	0.024
	Grass status	1	0.150
	Interaction	2	0.004
Class 6	Camera height	2	0.954
	Grass status	1	0.199
	Interaction	2	0.007
Class 7	Camera height	2	0.732
	Grass status	1	0.048
	Interaction	2	0.370

Class 8	Camera height	2	0.020
	Grass status	1	0.006
	Interaction	2	0.029
Class 9	Camera height	2	0.017
	Grass status	1	0.007
	Interaction	2	0.153
Class 10	Camera height	2	0.003
	Grass status	1	0.001
	Interaction	2	0.004

Only with the greyscale images, differences were directly identifiable on the histograms of each image (example of sample n°1 on Figure 2).
However for images taken at 30 cm and 40 cm, significant differences were visible (Table 2) for classes between 2 and 8. Intense dark pixels were more visible for grass before the cut, which is normal because of the presence of grass ($p<0.0001$). Although it was not significant, one can see that lighter pixels are present after the cuts simulating the passage of the animals (class 6 to class 9).

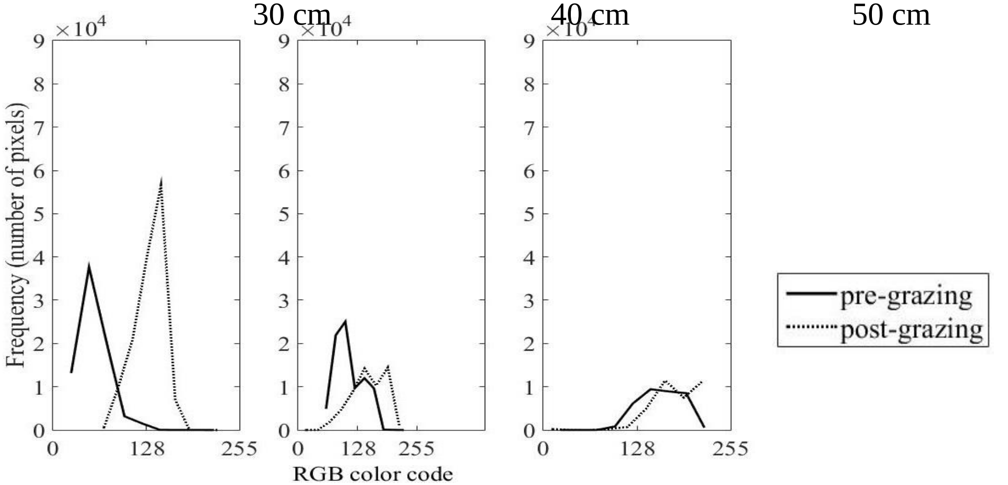


Figure 2: Histograms differentiating pre- and post-grazing greyscale images for sample n°1 at 30, 40 and 50 cm of heights above the ground.

This method has the advantage to be non-destructive as well as to be able to characterize the sward structure in details. However, to cover the whole pasture, it would be time-consuming unless representative samples would be taken into account. Hence, it does not seem quite feasible to use it as the vegetation counterpart to high rate animal biting monitoring. The other limit of this technique is sunlight as it was not possible to take good quality images without a shade tent. Finally, if the slope of the ground is high, biases might appear on the images taken at different place on the pasture. The use of tools enabling image acquisition at a high frequency could cope with this problem knowing that nowadays devices like drones are fitted with more sophisticated cameras. Coupled with an accurate location sensor the data could cover in one shot the whole pasture and improve the determination of the spatial distribution of the grass.

Conclusions

Histograms of intensity performed on greyscale images could detect differences between pre- and post-grazing sward. As expected, overall darker pixels were observed for pre-grazing images and whiter pixels for post-grazing images, indicating longer distances consistent with lower forage biomass. It could be concluded that use of camera would be a helpful tool for assessing the grass heights on pasture. Nevertheless, more automated methods should be investigated in order to accelerate the image acquisition and to sweep the whole pasture area reducing the duration of the measurements.

Acknowledgements

This work was initiated by the Precision Agriculture Unit of Gembloux Agro-Bio Tech (University of Liege, ULg), and performed with the help of all technical and scientific staff, with a special acknowledgement to Dylan Ruelle for his great contribution and dedication in the accomplishment of this research.

References

Andriamandroso, A. L. H., Bindelle, J., Mercatoris, B., & Lebeau F. 2016. A review on the use of sensors to monitor cattle jaw movements and behavior when grazing. *Biotechnology, Agronomy, Society and Environment*, 20(S1).

Andriamandroso, A., Lebeau, F., & Bindelle, J. 2015. Changes in biting characteristics recorded using the inertial measurement unit of a smartphone reflect differences in sward attributes. *Precision Livestock Farming'15*, 283-289.

Andújar, D., Dorado, J., Fernández-Quintanilla, C., & Ribeiro, A., 2016. An Approach to the Use of Depth Cameras for Weed Volume Estimation. *Sensors*, 16(7), 972.

Bonesmo, H., Kaspersen, K., & Bakken, A. K., 2004. Evaluating an image analysis system for mapping white clover pastures. *Acta Agriculturae Scandinavica, Section B–Soil and Plant Science, 54, 76–82.*

Boval, M., & Dixon, R. M. 2012. The importance of grasslands for animal production and other functions: a review on management and methodological progress in the tropics. Animal, 6(05), 748-762.

Carvalho, P. C. F., 2013. Harry Stobbs Memorial Lecture: Can grazing behavior support innovations in grassland management? *Tropical Grasslands-Forrajes Tropicales*, 1(2), 137-155.

Castro, E., Pérez, C., Ortega, C. A., Vizuete, D. S., & González, J. P. 2017. Evaluation of two hormonal stimulants for fattening Brahman bulls under grazing and supplementary multinutritional blocks. *SIEMBRA, 3(1), 101-104.*

Ehlert, D. Adamek, R. Und Horn, H.-J., 2009. Laser rangefinder-based measuring of crop biomass under field conditions. - *Precision Agriculture '10,* 395–408

Fan, X., Kawamura, K., Lim, J., Yoshitoshi, R., Yuba, N., Lee, H. J., Tsumiyama, Y., 2016. Spring growth stage detection in Italian ryegrass field using a ground-based camera system. *Grassland Science*, 62(3), 188-193.

Gebhardt, S., Schellberg, J., Lock, R. Kühbauch, W. "Identification of broad-leaved dock (Rumex obtusifolius *L.*) on grassland by means of digital image processing". *Precision Agriculture* 2006, 7, 165.

Gregorini, P., Villalba, J. J., Chilibroste, P., Provenza, F. D., 2017. Grazing management: setting the table, designing the menu and influencing the diner. *Animal Production Science*, in press.

Gibb, M. J. 1996. Animal grazing/intake terminology and definitions. *Pasture ecology and animal intake* 3, 21-37.

Girma, K., Martin, K. L., Anderson, R. H., Arnall, D. B., Brixey, K. D., Casillas, M. A., Chung, B., Dobey, B. C., Kamenidou, S. K., Kariuki, S. K., Katsalirou, E. E., Morris, J. C., Moss, J. Q., Rohla, C. T., Sudbury, B. J., Tubana, B. S., Raun, W. R., 2006. Mid-Season Prediction of Wheat-Grain Yield Potential Using Plant, Soil, and Sensor Measurements. *Journal of Plant Nutrition* 29, 873 – 897

Hodgson, J., 1985. The control of herbage intake in the grazing ruminant. *The Proceedings of the Nutrition Society* **44**, 339–346.

Macoon, B., Sollenberger, L. E., Moore, J. E., Staples, C. R., Fike, J. H., Portier, K. M. 2003. Comparison of three techniques for estimating the forage intake of lactating dairy cows on pasture. *Journal of Animal Science*, 81, 2357-2366.

Nadimi, E.S., Søgaard, H.T., Bak, T., Oudshoorn, F.W., 2008. ZigBee-based wireless sensor networks for monitoring animal presence and pasture time in a strip of new grass. *Computers and Electronics in Agriculture*, **61**, 79–87

O'Mara, F. P., 2012. The role of grasslands in food security and climate change. *Annals of botany*, 110, 1263-1270.

Porter, M.G., Barton, D., 1997. A comparison of methods for the determination of dry matter concentration in grass silage including an extraction method for water. *Animal Feed Science and Technology*, 68, 67-76.

Robert, F., Barnes, C., Jerry, N., Kenneth, J. M., Michael, C. 2007. *Forages: The science of grassland agriculture*. 808 p.

Sanderson, M. A., Rotz, C. A., Fultz, S. W., Rayburn, E. B., 2001. Estimating forage mass with a commercial capacitance meter, rising plate meter, and pasture ruler. *Agronomy Journal*, 93, 1281-1286.

Smit, H. J., Taweel, H. Z., Tas, B. M., Tamminga, S., Elgersma, A., 2005. Comparison of techniques for estimating herbage intake of grazing dairy cows. *Journal of Dairy Science*, 88, 1827-1836.

Yin, X., McClure, M.A. Jaja, N. Tyler, D.D., Hayes, R.M., 2011. In-Season Prediction of Corn Yield Using Plant Height under Major Production Systems. - *Agronomy Journal* 103, 923-929.

Zhang, L., Grift, T. E., 2012, A LIDAR-Based Crop Height Measurement System for Miscanthus giganteus. *Computers and Electronics in Agriculture* 85, 70-76.