Comparison of seasonal differences in infrared thermal images captured through a intelligent pasture monitoring system

Iliyan Damyanov[1]
Department of Combustion Engines, Automobile Engineering and Transport,
Faculty of Transport, Technical University of Sofia,
Sofia, Bulgaria,
idamyanov@tu-sofia.bg

Kalin Dimitrov[2]
Department of Radio communications and Video technologies,
Faculty of Telecommunications, Technical University of Sofia,
Sofia, Bulgaria,
kld@tu-sofia.bg

Tsvetan Valkovski[3]
Department of Radio communications and Video technologies,
Faculty of Telecommunications, Technical University of Sofia,
Sofia, Bulgaria,
cvalkovski@tu-sofia.bg

***Abstract*— This article is a continuation of our study of pasture research using aerial photography, focusing on seasonal differences in infrared thermal imaging in order to obtain a large database and relationships between different seasons and pasture quality.**

***Keywords*— unmanned aerial vehicle, aerial photography, aerial photogrammetry, image analysis, pastures**

I. INTRODUCTION

In our initial research, we focused on approaches to solving problems such as biodiversity conservation and grazing livestock by introducing modern methods and systems for optimization, monitoring and management of pastures.

In this study we will use an identical method of data acquisition [1-6], applying statistical methods to compare and find the relationships between seasonal differences in the emission of infrared thermal images taken by an unmanned aerial vehicle equipped with a specialized sensor system. This allows us to obtain spatial data, flexibly and continuously, and it is possible to study large areas without significant influence of weather conditions.

II. THEORY

In previous studies we focused on the construction of the system, the nature of photogrammetry and its advantages. Of interest in the current study are the differences from the images taken in an identical area.

The research was conducted in the territory of the town of Kardzhali in the Republic of Bulgaria with geographical coordinates 41 ° 29 ', using an unmanned aerial vehicle, software for three-dimensional photogrammetry and infrared sensor system.

The first study was conducted on 25.06.2021, which could be considered the peak time of the density of pasture mass. The next study was conducted on 21.10.2021, which can be considered as the end of the grazing season in relation to the climatic conditions in the study area. The coordinates are presented visually in Fig.1.

a

b

Fig. 1. Location 41°29'39.7"N and 25°28'44.8 "E (**a**) and view of the studied pastures (**b**).

For the purpose of conducting the experiments, an unmanned aerial vehicle PHANTOM aircraft model 3 with mounted boards with Melexis MLX90640 sensor during the flight and a thermographic camera Flir E40 were used. The aim is to capture both aerial and ground images.

This approach is extremely effective given that high mountain pastures and those with low productive potential occupy significant agricultural areas in Bulgaria. Such are areas in the Central and Western Balkan Mountains, Rila, Vitosha, Rhodopes, as well as in some parts of the heights in southern Bulgaria. Studies favor the improvement of biodiversity conservation factors in order to reduce the carbon footprint of agricultural activities, as required by the European Union in the Biodiversity Strategy to 2030. [7]

In addition to providing fodder for livestock, pastures are also important for the good biological development of the environment, such as biodiversity, water treatment, carbon treatment, erosion control and landscape protection. Keeping them in good ecological and agricultural condition is especially important for animal husbandry in order to lower the price of a product that is better quality and tastes better.

The composition of meadows and pastures in Bulgaria is made up of plant species, a collection of different botanical families with different nutritional value. This value is directly dependent on many factors such as geographical location, natural conditions, method of cultivation and proper land use. As part of these important factors is the proper management of pastures according to the seasonality of plant species and the ability to use the highest quality productivity of them. Against this background, for example, the targeting of grazing livestock to pastures could be optimized according to seasonal productivity, thus balancing the all-season quality nutrition, which would lead to increased product quality, optimization and reduction of the finished product and maintaining taste.

There are well-known conventional methods for estimating pasture productivity, but they are quite subjective, time consuming and difficult to implement for large areas. In recent years, more and more new technologies are entering, which leads to the development of a number of new methods for assessing the productivity of pastures through remote monitoring. This type of monitoring is through satellite images, aircraft images and specialized systems.

An important element in these methods is the filling and correctness of the data, they must be checked periodically in order to correct and objectively assess the quality of the grazing system. In addition, the more data available for comparison over time, the greater the opportunity to evaluate and prepare long-term plans for the operation and / or stabilization of a pasture area.

According to the so-called concept of Industry 4.0, the basis for improving the quality of crops are built-in intelligent systems that support automated control of technological and management processes, which is performed using artificial intelligence, algorithms for analysis of various parameters, improvement, monitoring and collection of databases set of parameters. [8-17]

III. RESULTS

In view of the presented theoretical data, we focus on the study of an identical object in two different seasonal periods, summer and autumn, respectively. The purpose of this experiment is to see if there is a relationship between the emission of identical grazing mass in different seasons.

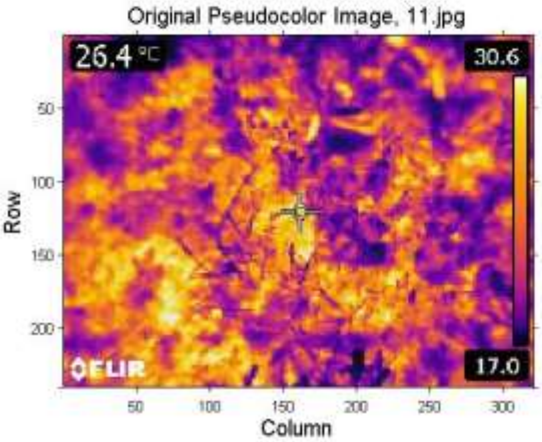
The selected image processing methods are visual and analytical. Figure 2 shows a picture of the studied pasture mass.

a

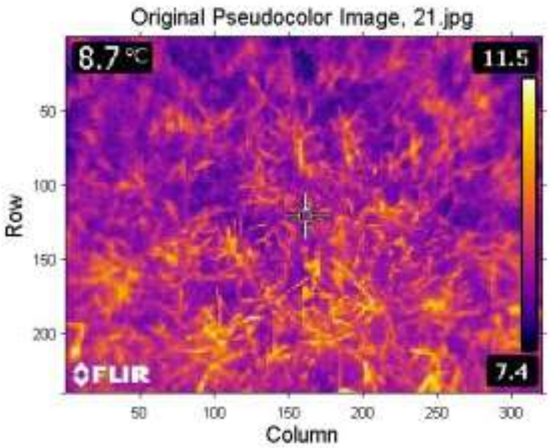
b

Fig. 2. The studied pasture mass during the first survey on 25.06.2021. (**a**) and during the second shooting on 21.10.2021. (**b**).

Figure 3 shows the thermographic images taken from the Flir E40 thermal camera for the two studied periods.



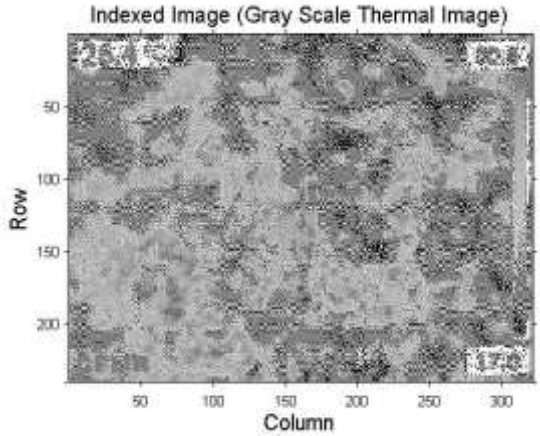
a



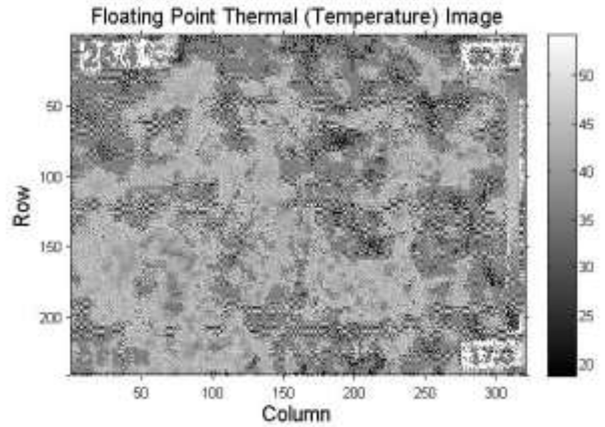
b

Fig. 3. Thermographic images of the studied pasture mass during the first survey on 25.06.2021. (**a**) and during the second shooting on 21.10.2021. (**b**).

After capturing the thermographic images, we perform processing by conversion to a halftone image and calibration of the converted halftone images in order to obtain correct histograms of the images. In FIG. 4 shows an example of the conversion of thermographic images to halftones and temperature calibration, respectively.



a



b

Fig. 4. Convert the thermographic image to halftone (**a**) and temperature calibration to extract the histogram (**b**).

When processing the images and obtaining a histogram, we have the opportunity to conduct a mathematical analysis of the data obtained, from which it is possible to assess the quality of the pasture mass. Figure 5 shows a general histogram for the captured image from 25.06.2021. marked as Ex B and that from 21.10.2021. designated as Ex A.

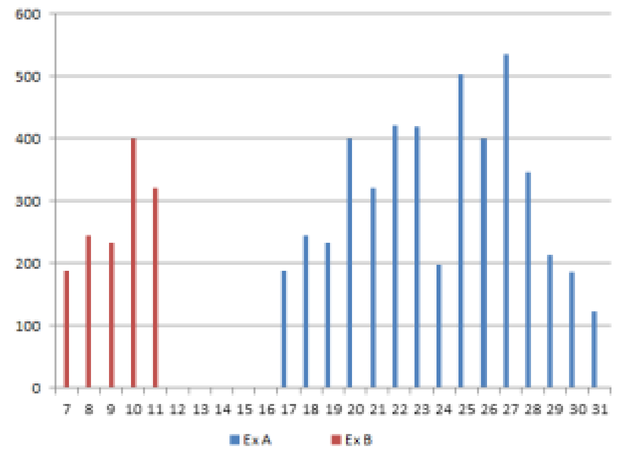


Fig. 5. Histogram of the obtained experimental images.

After receiving the reports from the images themselves, it is possible to perform another type of mathematical analysis for evaluation, such as the slope of the function. For this purpose we use Microsoft Excel software, as a result for the image from 25.05.2021. is 0.028, while for this from 21.10.2021. is -0.04.

Of course, these data may vary for different pasture masses and their biodiversity, such as in FIG. 6 we have attached a histogram from a study of three different pastures from the data collected during the summer period.

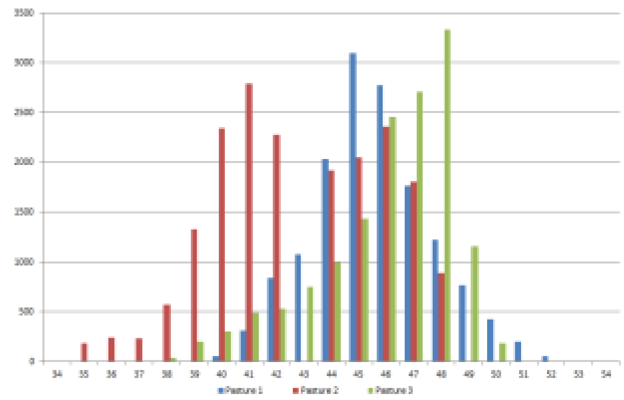


Fig. 6. Histogram of three different pastures from the data collected during the summer period.

As can be seen, these methods for visual and analytical assessment of pastures could be integrated into an intelligent system for monitoring agricultural activity in order to effectively use and maintain pastures.

III. CONCLUSION

In view of the results obtained, it can be said that these methods can be integrated into the so-called computer vision and machine learning, which are part of the main focus of Industry 4.0.

ACKNOWLEDGMENT *(Heading 5)*

The research leading to these results has received funding from the Ministry of education and science under the National science program INTELLIGENT ANIMAL HUSBANDRY, grant agreement № DO1-62/18/03/2021, RP7.

REFERENCES

[1] I. Sinde-González, M. Gil-Docampo, M. Arza-García, J. Grefa-Sánchez, D. Yánez-Simba, P. Pérez-Guerrero, V. Abril-Porras, „Biomass estimation of pasture plots with multitemporal UAV-based photogrammetric surveys,“ International Journal of Applied Earth Observation and Geoinformation, vol. 101, pp. 102355, 2021.

[2] J. Gillan, M. McClaran, T. Swetnam, P. Heilman, “Estimating Forage Utilization with Drone-Based Photogrammetric Point Clouds,” Rangeland Ecology & Management, vol. 72 (4), pp.575-585, 2019.

[3] J. Hadfield, B. Waldron, S. Isom, R. Feuz, R. Larsen, J. Creech, M. Rose, J. Long, M. Peel, R. Miller, K. Rood, A. Young, R. Stott, A. Sweat, K. Thornton, “The effects of organic grass and grass-birdsfoot trefoil pastures on Jersey heifer development: Heifer growth, performance, and economic impact,” Journal of Dairy Science, vol. 104 (10), pp.10863-10878, 2021.

[4] M. Pecina, T. Bergamo, R. Ward, C. Joyce, K. Sepp, “A novel UAV-based approach for biomass prediction and grassland structure assessment in coastal meadows,” Ecological Indicators, vol.122, pp. 107227, 2021.

[5] G. da Silva Vieira, B. Rocha, H. Pedrini, N. Sousa, J. de Lima, R. Costa, F. Soares, "Visual Detection of Productive Crop and Pasture Fields from Aerial Image Analysis," 2020 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE), pp. 1-4, 2020.

[6] K. Dimitrov, I. Damyanov, D. Saliev and T. Valkovski, "Pasture Research Using Aerial Photography and Photogrammetry," 2021 29th National Conference with International Participation (TELECOM), 2021, pp. 121-124, doi: 10.1109/TELECOM53156.2021.9659796.

[7] D.J. Gibson, Grasses and Grassland Ecology; Oxford University Press: Oxford, UK, 2009.

[8] B. Toskov, A. Toskova, S. Stoyanov, E. Doychev, „Architecture of Intelligent Guard System in the Virtual Physical Space,“, IEEE 10th International Conference on Intelligent Systems (IS), Varna, Bulgaria, IEEE, pp. 265-269. 2020.

[9] J. M. Marais, R. Malekian и A. M. Abu-Mahfouz, „LoRa and LoRaWAN testbeds: A review”, IEEE AFRICON, pp. 1496-1501, 2017.

[10] R. Darvishzadeh, C. Atzberger, A. Skidmore, M. Schlerf, “Map-ping grassland leaf area index with airborne hyperspectral imagery: A comparison study of statistical approaches and inversion of radiative transfer models”, ISPRSJ. Photogrammetry Remote Sens., vol. 66, no. 6, pp. 894–906, 2011.

[11] L. Olmanson, P. Brezonik, M. Bauer, “Airborne hyperspectral remote sensing to assess spatial distribution of water quality characteristics in large rivers: The Mississippi River and its tributaries in Minnesota,” Remote Sens. Environ., vol. 130, pp. 254–265, 2013.

[12] D. Stow, Y. Hamada, L. Coulter, Z. Anguelova, “Monitoring shrub-land habitat changes through object-based change identification with airborne multispectral imagery”, Remote Sens. Environ., vol. 112, no. 3, pp. 1051–1061, 2008.

[13] M. Lewis, V. Jooste, and A. A. de Gasparis, “Discrimination of arid vegetation with airborne multispectral scanner hyperspectral imagery”, IEEE Trans. Geosci. Remote Sens., vol. 39, no. 7, pp. 1471–1479, 2001.

[14] C.N.Scholten, A.J.Kamphuis, K.J.Vredevoogd, K.G.Lee-Strydhorst, J.L.Atma, C.B.Shea, O.N.Lamberg, D.S.Proppe, “Real-time thermal imagery from an unmanned aerial vehicle can locate ground nests of a grassland songbird at rates similar to traditional methods”, Elsevier. Biological Conservation, vol.233, pp. 241-246, 2019.

[15] H. Pelgrum, T. Schmugge, A. Rango, J. Ritchie and B. Kustas, "Spatial variability of thermal and near infrared imagery in JORNEX", IGARSS '98. Sensing and Managing the Environment. 1998 IEEE International Geoscience and Remote Sensing. Symposium Proceedings. vol.2, pp. 589-591,1998.

[16] L. Hui and Z. Chengjun, "3D visual simulation of grassland under random wind field", 2018 International Conference on Artificial Intelligence and Big Data (ICAIBD), pp. 155-159,2018.

[17] G. Pajares, Overview and Current Status of Remote Sensing Applications Based on Unmanned Aerial Vehicles (UAVs), Photogrammetric Engineering & Remote Sensing. vol. 81(4),pp. 281-329, 2015.