Use of thermography methods for monitoring grazing livestock

Tsvetan Valkovski[1], Durhan Saliev[2] and Iliyan Damyanov[3]

Abstract – **This paper explores the possibility of recognizing and separating the individual biological units in a particular field of study. The aim is to separate the different biological units and distinguish them by species such as cattle, smaller domestic animals and carnivores. It is possible to determine the number and localization of animals from the analysis of photographic material captured by unmanned aerial vehicles and processed by software.**

Keywords – **thermography, monitoring, livestock, artificial intelligence, industry 4.0, bio system.**

I. Introduction

The aim of the study is the continuation of the research conducted on the populations of different animals presented in our previous articles. The possibility of remotely photographing large areas through standard and thermographic cameras is a reason for carrying out this type of monitoring. Innovative methods [1] are increasingly used in Industry 4.0 as they offer high efficiency and real-time insight. Optimizing and controlling pastures and the animals that inhabit them is a prerequisite for minimizing incidents related to predators, for example [2]. Determining the number and monitoring from a distance also do not affect the natural behavior of the animals, which is especially important for grazing animals - their stress and anxiety affects milk production, meat quality and a bunch of other factors.

II. The Idea

The experimental study was conducted using a variety of imaging approaches in the designated area of interest.

The main type of filming used for the experiment is aerial or so-called aerial photography with unmanned aerial vehicles. The advantage of this method is the possibility of distance and filming from a relatively distant point of view, thus avoiding direct contact with the studied objects - animals. This is extremely important to prevent domestic or wild animals from becoming uncomfortable and changing their behavior towards their environment and habitat. Such type of factors naturally directly affect cattle and small cattle raised for meat and milk. By creating discomfort in the animals, it affects the production qualities of the meat and milk yield, as well as the overall health and normal reproductive habits of the animals. This also applies to wild animals, through this type of filming it is possible to monitor populations of endangered animals as well as dangerous predators. To predict their movement, habits and territories, thus to make a clearer analysis of the distribution of pasture areas and, in general, to make it possible to organize a plan for the biobalance of the studied area or region. Even studies indicate that thanks to this type of recording and analysis of the images, conclusions can be drawn about the general physical and emotional state of domestic and wild animals in relation to their habits, migrations, etc. [3] It is the so-called temperament of biological units or "a consistent physiological and behavioral difference observed between different species and individuals in response to environmental change or the presence of stress, which has been used to analyze the relative difference in behavior and character of the unit " [4,5]. The drone used is shown in figure 1, and the characteristics of the camera used are presented in table. 1.

Fig.1 Photo of the unmanned aerial vehicle used for the research in one of the laboratories of the Technical University.

[1]Tsvetan Valkovski is with Technical University of Sofia, Faculty of Telecommunications, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: cvalkovski@tu-sofia.bg

[2]Durhan Saliev is with Technical University of Sofia, Faculty of Transport, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: durhan_saliev@ tu-sofia.bg

[2]Ilian Damyanov is with Technical University of Sofia, Faculty of Transport, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: idamyanov@ tu-sofia.bg

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TABLE I. MAIN CAMERA SPECS

Thermographic sensor	Unvented VOx Microbolometer
Sensor resolution	640×512 @30Hz
Video resolution	640×512@30fps
Visual camera sensor	1/2" CMOS, Effective Pixels: 48 MP
Sensor resolution	8000×6000
Video resolution	3840×2160@30fps 1920×1080@30fps
Sensory system	Obstacle detection in all directions
Maximum speed	72 kph (S-mode, without wind)
Maximum height	6000 m (above sea level)
GNSS	GPS+GLONASS
Operating frequency	2.4-2.4835 GHz; 5.725-5.850 GHz
Built-in memory	24 GB
FOV	(Forward) Horizontal: 40°, Vertical: 70° (Back) Horizontal: 60°, Vertical: 77° (Down) Forward and backward: 100°, Left and right : 83° (Side) Horizontal: 80°, Vertical: 65°
Maximum flight time	31 minutes (measured at 25 kph flight without wind); 28 minutes (with added RTK module); 29 minutes (with beacon on); 30 minutes (with beacon off); 24 minutes (with spotlight on); 28 minutes (with spotlight off); 27 minutes (with speaker on); 28 minutes (with off loudspeaker)
Work temperature	-10° to 40° C

The data is then transmitted over a wireless communication channel for connection to a master device for image processing and analysis. This telecommunication wireless channel is implemented through a radio frequency connection, and depending on the transmission distance, it is possible to use a private or public network with the appropriate security certificates for data transmission. The main advantage of using radio communication methods is the large range, as well as the high speed of information transmission. Nowadays, there are also developments for the automated control of unmanned aerial vehicles, as this provides prerequisites for the future development of the system so that it is fully autonomous, without the need for constant monitoring and control by a person [6,7]. Thus, when mapping the area, it is possible for the drone to be controlled by an aerial system that guides its movement. Accordingly, the advantages, in addition to automation of the system, is also the possibility of starting permanent work with interruptions only for charging the batteries or their replacement by a person responsible for the maintenance of the system. This results in very high efficiency and constant live monitoring of the specified area, which could be a pasture, rugged terrain, forest, arable land, populated area, and others.

Once the transmission of the collected visual and thermographic images from the drone has been carried out, it is possible to analyze the collected images, through which conclusions and predictions can now be made about the above-mentioned characteristics of domestic and wild animals.

All collected images are collected in a single adaptive database, which, as the system progresses over time, becomes larger and larger. This, in turn, leads to an increase in the accuracy and fidelity of the obtained results and provides an option for predicting events such as migrations of certain biological units, monitoring the development of populations, monitoring biodiversity and others.[8]

A basic block diagram of this data acquisition algorithm is presented in Figure 2. It presents the steps to implement and operate such a system.

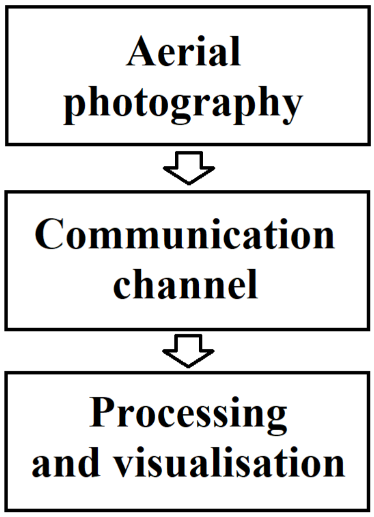


Fig.2. Block algorithm of thermography methods for monitoring grazing livestock.

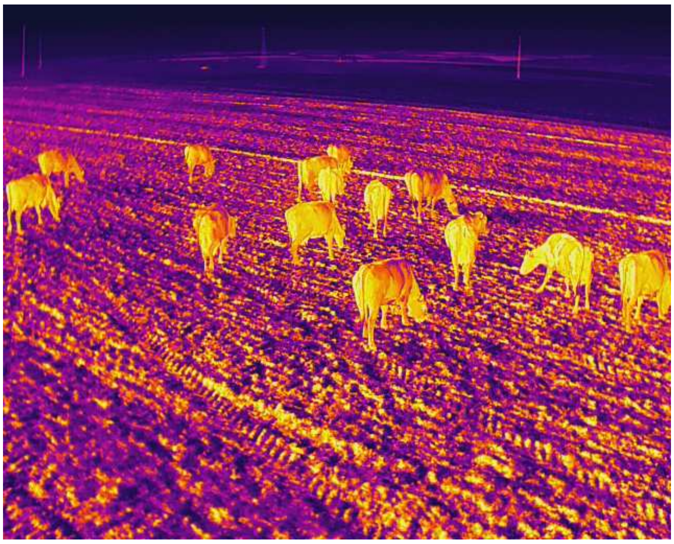
The aerial photography block includes all the processes of capturing visual and thermographic images. The communication channel block includes the method of transmitting the data from the UAV to the central device for processing and analyzing the results. The processing and visualization block includes the methods for processing, analyzing and synthesizing the input images and obtaining and visualizing the output data.[9,10]

III. EXPERIMENTS

After considering the theory and developments on the subject, we have formed the complete system including the drone for the moment with manual remote control by a pilot, the communication channel is implemented in two ways - passive and active. The passive communication channel is by storing the images in the internal memory of the drone. The active communication channel is through transmission over a radio communication channel for connection to the main device - a portable computer. The final unit of the system is a portable computer with appropriate Octave-based software for processing and analyzing the obtained images.

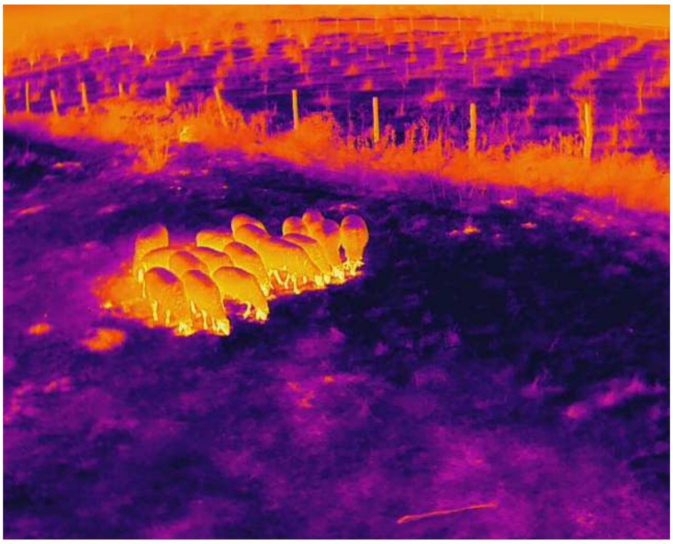
The shooting of the images took place on 30.10.2022 in the area of Momchilgrad. Figure 3 presents visual and thermographic aerial images of cattle and sheep.

a



b

c



d

Fig.3. Captured visual and thermographic images of cattle ***a b*** and sheep ***c d***

After capturing the images, we have formed an initial database of over 1000 different images and using Octave's object recognition algorithm, we have performed the recognition of individual entities such as cows, sheep, humans, predators and others. An example of the recognition is given in Figure 4. a cow recognition is presented here and in Figure 5. a “hidden” human in woods and a group of biological units – sheeps recognition is presented here.

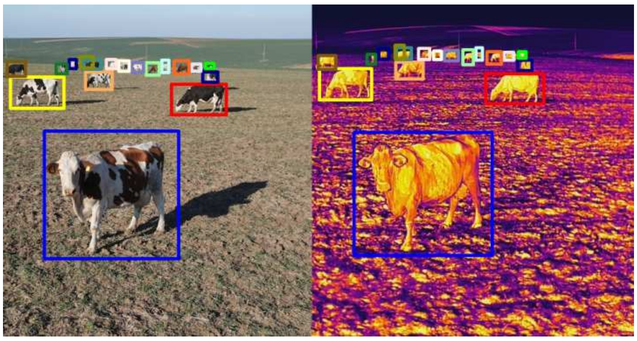


Fig.4. Cattle recognition

Fig.5. “Hidden” human in woods and a group of biological units – sheeps recognition

As can be seen in Figure 4 and 5, in addition to the recognition of the individual, the other biological units captured by the visual and thermographic cameras are also located. This is a prerequisite for the development of the system with possibilities for multiple monitoring by recognizing different biological units, counting their populations, detecting predators, people and other objects.

From the example presented in Figure 5, it clearly shows that thanks to thermographic cameras, we also have the opportunity to observe in forests and bushes. For example, it is possible to observe a hidden person, predator or livestock.

These goals are the basis for future developments on the subject. Along with the gradual filling of the database with images, new capabilities will be added, such as the previously mentioned reporting of various natural factors affecting biological units and capabilities to predict typical migrations and processes in them.

IV. Conclusion

In view of the presented idea and the experimental research carried out, the following conclusions are clear:

The larger the image database, the more accurate results can be achieved.

Thanks to the development of artificial intelligence, it is possible to realize intelligent recognition of different biological entities by entering their typical radiation temperatures.

When using more optimized software, it is possible to monitor multiple parameters.

According to the arguments described above, this method would find wide application in the infrastructure of Industry 4.0 and the monitoring of biological units, monitoring the populations of both domestic and wild animals. Which is important for maintaining the biobalance in our nature.

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References

[1] Damyanov, I. S., Implementation of advanced software solutions and systems for transport traffic research and control, 9th International scientific conference “Techsys 2020”, IOP Conference Series Materials Science and Engineering DOI: 10.1088/1757-899X/878/1/012044

[2] Damyanov, I. S., Use of modern software solutions and systems for analysis and reconstruction of road accidents, 9th International scientific conference “Techsys 2020, IOP Conference Series Materials Science and Engineering DOI: 10.1088/1757-899X/878/1/012043

[3] Edwards, S.A.; Broom, D.M. (1982). "Behavioural interactions of dairy cows with their newborn calves and the effects of parity". Animal Behaviour. 30 (2): 525–535. doi:10.1016/s0003-3472(82)80065-1.

[4] B. Brand, F. Hadlich, B. Brandt, N. Schauer, K. Graunke, J. Langbein, D. Repsilber, S. Ponsuksili, M. Schwerin, Temperament Type Specific Metabolite Profiles of the Prefrontal Cortex and Serum in Cattle, DOI: 10.1371/journal.pone.0125044.

[5] Réale, D.; Reader, S.M.; Sol, D.; McDougall, P.T.; Dingemanse, N.J. (2007). "Integrating animal temperament within ecology and evolution". Biol. Rev. Camb. Philos. Soc. 82 (2): 291–318. doi:10.1111/j.1469-185x.2007.00010.x. hdl:1874/25732. PMID 17437562. S2CID 44753594.

[6] Iliev, I., & Nachev, I. (2022). Automatic Landing of Unmanned Aerial Vehicles via Wireless Positioning System with Pseudo-Conical Scanning. Sensors, 22(17), 6451.

[7] I. Nachev and I. G. Iliev, "Circularly Polarized Phased Antenna Array with Pseudo-Conical Scanning with an Application for UAVs Unmanned Landing," 2022 30th National Conference with International Participation (TELECOM), Sofia, Bulgaria, 2022, pp. 1-4, doi: 10.1109/TELECOM56127.2022.10017320.

[8] H. Hristov, K. Dimitrov and T. Penev, "Use of Infrared Thermography to Monitor the Physiological Condition of Dairy Cows," 2021 12th National Conference with International Participation (ELECTRONICA), Sofia, Bulgaria, 2021, pp. 1-4, doi: 10.1109/ELECTRONICA52725.2021.9513724.

[9] H. Hristov, T. Penev and K. Dimitrov, "Use of infrared thermography to detect heat stress in dairy cows," 2021 XXX International Scientific Conference Electronics (ET), Sozopol, Bulgaria, 2021, pp. 1-4, doi: 10.1109/ET52713.2021.9579882.

[10] H. I. Hristov and K. L. Dimitrov, "Investigation of the influence of the distance and the angle of observation in radiometric measurements in the infrared spectrum," 2022 57th International Scientific Conference on Information, Communication and Energy Systems and Technologies (ICEST), Ohrid, North Macedonia, 2022, pp. 1-4, doi: 10.1109/ICEST55168.2022.9828683.