# Study of the cattle population with the help of remote digital photography and videography

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***Abstract*— This article examines the possibility of recognizing the individual biological units of a specific cattle population, determining their number and physical condition from digital images, using software solutions and systems on a particular pasture.**

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## I. Introduction

The main argument in research conducted on populations of different species of animals is animal welfare. The introduction of innovative methods and systems for monitoring [1,2], control and optimization of the cattle population is the only correct approach to increase productivity in the field of dairy production and cattle breeding. Remote determination of the number and physical condition of biological units is essential in animal husbandry. Visual tracking of biological units and the use of digital images to determine key indicators and characteristics of entire herds of animals is increasingly used. The aim of this study is to investigate the potential of intelligent methods for tracking cattle populations.

## II. Theory

For the purposes of the experimental study, different approaches were used to capture digital images of biological units:

1. Aerial photography - by aerial photography using an unmanned aerial vehicle and analysis of the obtained images. The main advantage of using an unmanned aerial vehicle is that it provides the ability to shoot from a distance, avoiding the need to shoot in a place that could cause discomfort in cows and can directly affect production characteristics such as the quality of the meat or milk, as well as to affect the overall health and reproduction of the animal when filmed on site. Another advantage of the possibility of capturing video images taken by an unmanned aerial vehicle is that they were taken over the population of studied biological units, instead of the pasture itself.

From the captured digital images of cows, information about the general physical and emotional state can be extracted, and the position of the ears in cows is known to be studied as indicators of their emotional state and general welfare of animals [3]. Bovine temperament is defined as "the consistent behavioral and physiological differences observed between individuals in response to environmental stress or challenge and is used to describe a relatively stable difference in an animal's behavioral predisposition that may be related to psychobiological mechanisms" [4]. Generally, cattle temperament is assumed to be multidimensional. Five underlying categories of temperament traits have been proposed [5]: shyness – boldness, exploration – avoidance, activity, aggressiveness, sociability. Moreover, in the case of aerial photography [6-10], both the characteristics of the pastures inhabited and fed by the studied animal population and the meteorological situation at the time of the survey can be determined. The unmanned vehicle 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.

TABLE I. CAMERA SPECS

| | |
|---|---|
| Sensor | 1-inch CMOS, Effective pixels: 20M |
| Lens | FOV 84° 8.8 mm/24 mm (35 mm format equivalent) f/2.8-f/11 auto focus at 1 m-∞ |
| ISO Range | Video:<br>100-3200 (Auto)<br>100-6400 (Manual)<br>Photo:<br>100-3200 (Auto)<br>100-12800 (Manual) |
| Mechanical Shutter Speed | 8-1/2000 s |
| Electronic Shutter Speed | 8-1/8000 s |
| Image Size | 3:2 Aspect Ratio: 5472×3648<br>4:3 Aspect Ratio: 4864×3648<br>16:9 Aspect Ratio: 5472×3078 |

2. Terrestrial imaging, using a thermal camera to obtain thermographic images and analysis of the obtained images. Thermographic methods are used to remotely read the temperature distribution of biological units using a Flir E40 thermographic camera, Table 2.

TABLE II. FLIR E40 MAIN CHARACTERISTICS

| | |
|---|---|
| IR RESOLUTION | 19,200 (160 x 120) |
| THERMAL SENSITIVITY | <0.07°C (70mK) |
| FIELD OF VIEW | 25°H x 19°V |
| TEMPERATURE RANGE | -20 to 650°C (-4 to 1202°F) |
| FRAME REFRESH | 60 Hz |
| FOCUS | Manual |
| MEASUREMENT MODES | 5 modes: 3 spots, 3 area boxes (min/max), Isotherm (above/below), auto hot/cold, Delta T |
| ACCURACY | ±2% rdg. or 2°C |

## III. RESULTS

At the first stage of the research the method was used by using an unmanned aerial vehicle and aerial photography of digital images of biological units. During the study, the unmanned aerial vehicle was raised at different altitudes in the range of 30 to 50 meters, and the time for video recording of the movement of the biological unit is at different intervals (fig.2). When shooting from a lower, which is more appropriate, the herd of cows is initially intrigued by the noise and type of drone, but after a while the animals are afraid of noise, which causes anxiety and irritation in which the cows run away in different directions of the studied pasture.


Fig.2. Aeroimages of cattle

The use of a high-resolution camera allows to achieve high quality images and recordings, providing the opportunity to track the movement of each biological unit, and hence to obtain relevant data on the herd. The images provide an opportunity to determine the general physical and emotional state and provide opportunities to study some indicators determining the emotional state and general welfare of animals.

The information from the recorded videos is processed by software by connecting data for images (video), georeferenced, explanations and trajectories, tracking, etc. The tracked biological units can be understood either as an object that always has an immediate position, or as a complete trajectory in space-time. The type of the monitored biological units in the herd (calf, cow, buffalo, etc.) is determined by software, during the analysis it is determined and monitored by different parameters: geometric dimensions; shape and speed of movement. The other statistical parameters in the initial analysis are the following: total distance traveled, total time followed by all recognized objects, average speed, distance between objects, etc. [7-17]

The trajectory of the identified biological units in the herd consists of a trajectory line and a marker in the form of a label with a flag and an identification number. The entry can be selected by clicking on its label. The list of biological units is for everyone who has been found (recognized) in the given video sequence. Each trajectory cannot be selected by marking on its record providing the following information:

- unique identification number of the animal.

- classification of the bovine type.

- current speed absolute size of the current speed vector.

- tangential acceleration of the cow [ms2] - a positive value means acceleration and a negative value means deceleration.

- lateral acceleration of the biological unit [$ms^2$] - positive value means acceleration to the right and negative value means acceleration to the left.

- the average speed of the cows in the herd [m/s].

- duration of movement and stay of cows spent on the studied pasture, expressed in seconds.

In the analysis of data, linear identifiers can be used, divided into three groups: input, output and neutral. The following data are available for each: identifier number; explanation to him; number and type of cattle passed through the identifiers; time and speed for passing between the individual identifiers, etc. It is possible to export the data in CSV format.

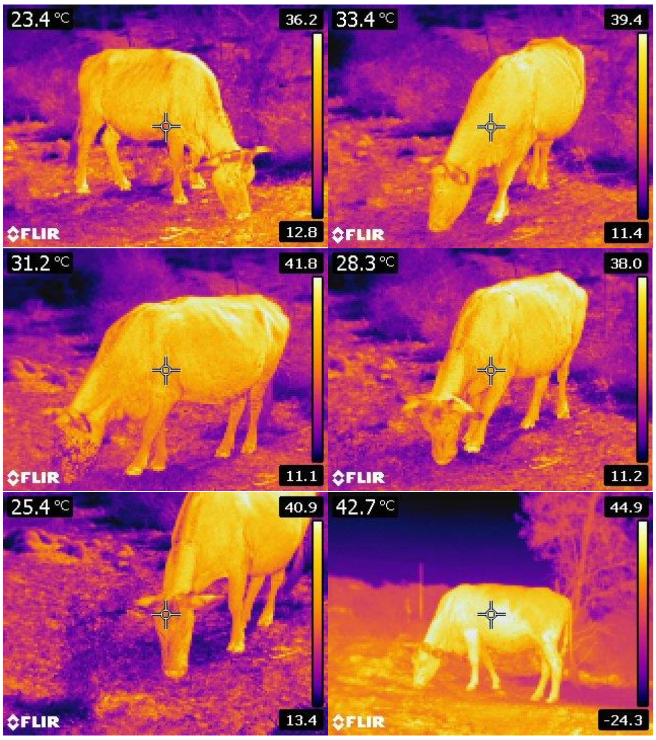
Simultaneously on the same pasture and at the same time when shooting from the air with the drone, ground shooting was performed using a thermal camera. Research using and analyzing thermographic images can be used as a diagnostic tool for the health status of the biological unit. In modern breeding of biological units (cows) the most common diseases are related to breeding technology, nutrition, labor organization, micro and macro-climate, and herd health monitoring programs. The health status of cows can be examined and monitored by infrared thermographic method - thermo diagnosis. The infrared camera can visualize and quantify changes in the surface temperature of cow skin and can be considered a non-invasive diagnostic tool and can be used for early diagnosis of pathology of the biological unit. The method can be used in various medical applications and monitoring. With this diagnostic method, the thermal differences in the studied areas can be compared with the same reference area on the opposite side of the body of the biological unit. Temperature is one of the main indicators of the state that determines the health system of all living organisms. In medicine, the change in temperature is a basic and noticeable feature of the ongoing disease process, and it is necessary to monitor, and the observed values need to be analyzed, and the interpretation of analysis results are objectified according to modern science and medicine.

Thermo diagnostics is a study that provides information for a timely response and can localize many diseases at an extremely early stage. The use of thermo-visual diagnostics in the process of breeding cattle considering the temperature deviations will improve the welfare of both individual cattle and whole herds of animals. Temperature anomalies in the bodies of all animals accompany all types of diseases: bacterial, viral, traumatic, oncological and others.

The normal temperature for cattle is 37.5-39 ˚C. Small deviations up or down are allowed, which are explained by the individual characteristics of the organism. The body temperature readings of young calves differ from those of adult animals and vary with the age of the calf.

| Age of the calf | Temperature ° C |
|---|---|
| 2-6 weeks | 38,5-41 ° C |
| Up to 2 months | up to 40,2 ° C |
| Up to 1 year | up to 40 ° C |
| More than a year | 37.5-39 ˚C |

Images from the field test, as well as the variations in the heat flux of the biological unit during the study are presented in Figure 3.



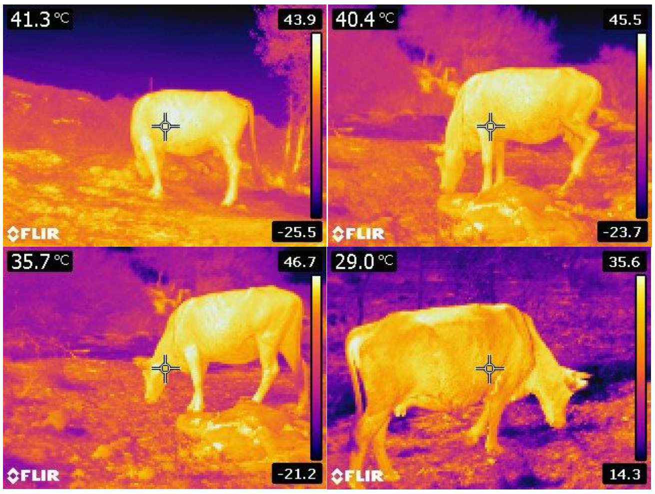




Fig.3. Variation of cattle temperature distribution

From the point of view of the health condition of the cow it is more important to study and analyze the distribution of temperature both on the whole body and on the individual limbs, muscles, organs, etc. This distribution is directly influenced by the activities and functions of the organs of the body and can give a clear idea of the overall condition of the animal and its specific organs. For this purpose, areas of interest are selected to monitor and analyze the temperature distribution of the cow's body. Since the study of individual organs and parts of the cow's body is a multifaceted task, several specific points from the cow's figure will initially be selected, as shown in Figure 4.

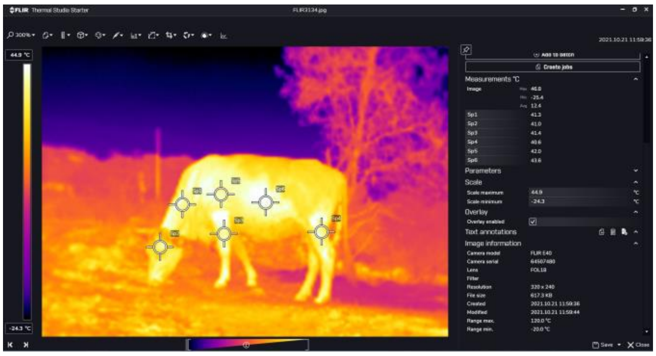


Fig.4. Regions of interest for determining the temperature distribution of cattle.

As mentioned in the above work, body temperature is a key indicator by which the health status of a biological unit can be determined. It is necessary to accumulate a large database of measurements of the temperature of individuals in the herd to determine pathological changes in their bodies, especially since the body temperature of cattle changes with the age group in which it falls. The analysis of the heat radiation of live animals is a rich source of information for changes in their health as well as cooling, overheating and others. in the process of their cultivation, regardless of the purpose of cultivation.

## IV. CONCLUSION

After performing the initial experimental study, some general conclusions can be made:

It is necessary to accumulate a large database of body temperature distributions of cows according to the age group in which they fall.

It is necessary to accumulate a large database of digital images to determine the behavior and emotional state of each animal individually and the well-being of the whole herd.

It is necessary to use a more specialized drone, emitting low noise levels (so as not to subject the cows to stress during the flight on them) and if possible equipped with a thermal camera, which will provide the ability to simultaneously capture images of the studied population of cows.

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