Agricultural, Forest and Transport Machinery and Technologies (ISSN: 2367– 5888)
Volume IX – Issue 1, 2022

Study of Animal Detection in Agricultural Work by Thermography

Pavol Findura, Peter Bartos, Hristo Beloev, Miroslav Pristavka, Zbynek Havelka, Radim Kunes, Lubos Smutny, Pavel Olsan, Erik Lavrík

Abstract: *The object of the research was to verify the functionality of selected technical equipment aimed at detecting game by which we try to prevent damage to game by agricultural machinery and related procedures enabling sustainable management leading to biodiversity support. For these purposes, we used thermography methods whereby, the sensors have a robust metal construction, which determines that they should be able to cope with shocks and vibrations. From measurements and subsequent calculations, we found that the success rate is greater when the viewing angle is more perpendicular to the ground. The question here is how large the field of view of the sensor is. Measurements have shown that the optimum distance for taking measurements is between 10 and 20 metres. In the measurements, the height of the placement of the thermal imager proved to be very important. If a higher height is chosen, the detection success rate will be higher.*

Keywords: *image analysis, animal detection, thermography, forage harvesting*

INTRODUCTION

The strategic objectives of the EU agricultural sector respond to global, European and Slovak-specific development problems and challenges. At a time when we are optimising our own production in order to ensure the self-sufficiency and profitability of Slovak agriculture, we are increasingly focusing on climate change, mitigation and subsequent adaptation; dealing with drought, torrential rainfall, water retention in the landscape, erosion and soil degradation. Biodiversity is also important and related. We regularly see wildlife killed or harmed in our fields or meadows during forage harvesting (Demo, 2019).

A certain solution is the prevention or diversion of game with newly established ecologically oriented areas of biobelts and clover grasslands. Increased plant biodiversity is usually accompanied by increased abundance and recovery of populations of field birds and other wild animals, especially small game (Weterings, et al., 2016; Wrzesień a Denisow, 2016; McCollin, 2000).

The use of high-performance and wide-ranging agricultural mechanization generates beyond the profitability of the subsequent production so-called externalities associated with significant negative impacts on wildlife, so we tried to look for ways to solve this problem with this research.

MATERIALS AND METHODS

The problem of game detection is being addressed by researchers from different countries. Marada et al. (2020) attempted to detect wildlife using a thermal sensor that operated at long wavelengths. In their experiment, they used a FLIR thermal imaging camera that was mounted on a tractor. It was at a distance of 4.75 meters from the crop and at an angle of 75° perpendicular to the ground. The working width was 2.1 metres. Two types of animals were used namely rabbit and hen. The aim was to observe the different thermal characteristics between the feathered and fur-bearing animals. Feathers were found to have better insulating properties than fur. The experiment was repeated at different working speeds. For the rabbit, it was 4 to 15 km/h and for the hen, it was 5 to 15 km/h. They found that the temperature of the beast would be significantly higher than the ambient temperature and hence the beast would be well visible on the thermal camera. However, as the day progressed, the environment became warmer and the difference between the ambient temperature and the game was reduced. This caused impaired detection. They decided to use a Gaussian filter (Steen et al. 2012).

$$\nabla^2 h(r) = \left[\frac{r^2 - \sigma^2}{\sigma^4}\right] exp\left(-\frac{r^2}{2\sigma^2}\right) \tag{1}$$

$$r^2 = x^2 + y^2 \tag{2}$$

Note: x2, y2 – size of the filter mask
σ – defocus parameter

The object of investigation was the use of Pulsar TRAIL XP50 thermal imager for game detection, during forage collection and HikMicro Thunder PRO TH35PC thermal imager. It was necessary to determine whether the device was suitable for such use, to devise a place for mounting on the machine and to find out at what height and distance the device should be mounted. The object of the investigation was the game itself in the undergrowth under different conditions.

The measurements were carried out on agricultural land in the village of Dolný Ohaj in southwestern Slovakia. In the structure of crop production, in addition to traditional crops such as wheat, maize, barley, oilseed rape, sunflower and fodder crops, PD Dolný Ohaj has a more than 40-year tradition of poppy cultivation. There is also a tradition of winemaking. It is the crop structure that creates good conditions for small game and furbearers.

We used a Plusar TRAIL XP50 thermal imaging camera for game detection. The thermal camera is equipped with a sensor with a resolution of 640 x 480 pixels. The pixel pitch is 17 μm. The focal length of the lens is 50 mm and the aperture is 1.2. The thermal imager has the ability to record video in .avi format or create photos in jpg format. The built-in internal memory is 8 Gb. Increased water resistance IPX7 according to IEC standard 60529. The refresh rate is 50 Hz, smoothly handles even dynamic tracking. Rechargeable battery capacity is 5.2 Ah.

An advantage is the built-in Wi-Fi, which allows you to connect your device to the thermal imager via the Stream Vision app. The app includes a motion detection feature. It can then be set to automatically detect objects in the field of view. It is possible to select the accuracy of detection according to the size of the object and the method of notification, which can be audible or vibrating.

StreamVision is an app that connects to the thermal imaging camera via Wi-Fi. The app allows you to detect a moving object in the field of view of the optical instrument. It allows you to select the accuracy of detection based on the size of the object and the selection of the type of notification, which can be either sound or vibration. The second thermal imager placed on the tractor was the Hikmicro Thunder PRO TH35PC. The Hikmicro Thunder Pro TH35PC (HM-TR13-35XG/W-TH35PC) thermal imaging pre-camera has a 384×288px resolution core, <35mk sensitivity and a 1024x768 OLED display, a high quality 35mm lens with rangefinder.

The powerful VOx 12m imaging sensor with NETD<35mK and a large aperture F1.0 lens ensures perfect target resolution and clear, detailed images even in complete darkness. 50 fps (frames per second) provide smooth and dynamic video. As before, we can forward images online.

The thermal imaging camera was placed on a Fendt 820 tractor, an older model from the 800 series. The cab concept is slightly modified from the higher performance 900 series. The 800 series model has excellent operating ergonomics. The tractor is equipped with automatic air conditioning, an air-conditioned storage box and a heated seat. The pneumatic three-point axle suspension ensures high comfort. Of course, the suspension axle and seat are also available. The advantage is the new type of lighting that covers 360 degrees and uses LED technology. The terminal includes a touch screen and is fully ISOBUS compatible.

Measurements in which game was detected were carried out in stands of meadow clover

(Trifolium pratense) and winter wheat (Triticum aestivum). The first measurement was at a height of 180 cm from the surface. For each type, we chose the distances from which we would try to detect game. We decided to take measurements at four different distances. The distances were 5, 20 and 30 metres. We wanted to find out at which distance the measurement was most successful.

For each distance, we took 30 measurements in different conditions. We then determined the percentage success rate. We repeated the measurements at different times of the day. The results of the success rate varied slightly depending on the weather, so we also recorded the climatic conditions during the measurements.

The Garni 975 is a professional weather station. The LCD display is used for display. It can measure relative humidity. It can measure precipitation, wind speed, wind direction, and temperature using the built-in sensor. The wind speed displays the average, over the last 30 seconds. It can distinguish 16 different airflow directions. At the same time, it measures barometric pressure. It also displays the outdoor dew point. Includes its own memory, which is able to record minimum and maximum values with time data for the last 24 hours.

RESULTS

Results of assessment of climatic conditions

The average daily temperature during the period when the experiments were conducted was 25.5°C. We recorded the average humidity during the day in a table. The average humidity in the month of May was at 70.6%, the measured climatic data shows that the lowest humidity during this period was just at the beginning of the month of May when we also carried out the measurements. The stands were sufficiently dry and the measurements were thus not affected by the wet surface of the forage. The average humidity was 52 % during the measurements. It was one of the driest days and well below average.

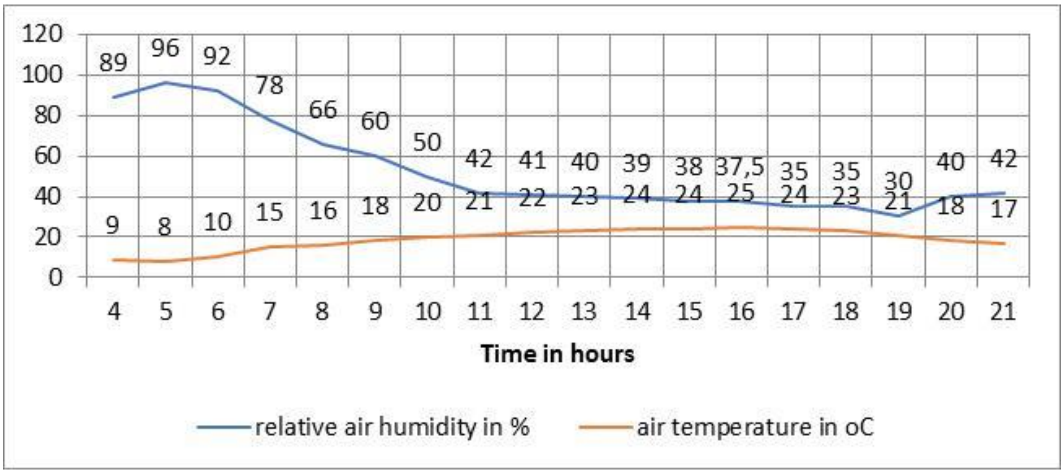

Fig. 1 The results of the climatic conditions in the measurements

Detection device quality assessment results

The experiments were conducted in crop stands where the most frequent encounters between machinery and wildlife occur. We started the measurements with a distance of 5 meters. We performed several repetitions. At this distance, detection was 100 percent. It did not depend on the height at which the thermal camera was placed, but also on the density and type of vegetation. However, this distance is not relevant in our work, so we focused on larger distances in more detail. We chose 10 metres as the next distance. We chose two different environments. The first denser one as seen in the photo on the left and a thinner stand with less leaf thickness in the photo on the right. We found that even at this distance, it does not matter from what height the thermal camera is sensing and the type of vegetation does not matter either.

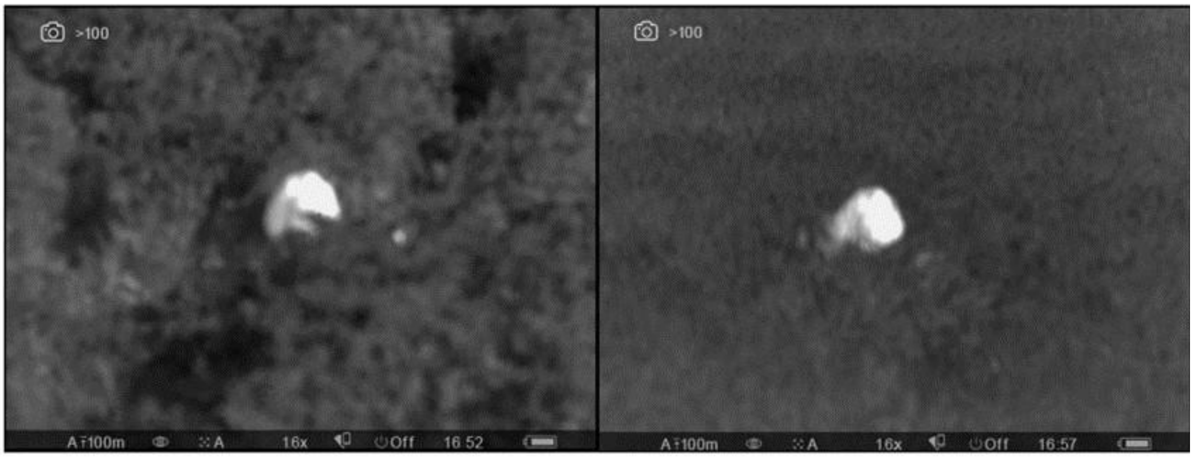

Fig. 2 Thermographic record on the left in a stand of meadow clover (Trifolium pratense) and winter wheat (Triticum aestivum) at a detection distance of 10 m and a height of 180 cm

We then changed the distance to 20 metres. This measurement corresponds to Figure 3. Immediately we found that with this distance it is not only the height of the stand that matters, but also the height from which the image is taken. On the left is an image taken from a height of 180 cm above the ground. When we compared this image with the one we took at 350 cm above the surface, we found that a larger piece of the object being imaged was visible in the image. This also had an effect on the detection. We then repeated both the type and distance measurements in a stand of wheat. This measurement is shown in Fig. 4. In these images, the difference caused only by the height and angle of the scan can be seen more clearly.

Fig. 3 Thermographic record on the left in a stand of meadow clover (Trifolium pratense) at a detection distance of 20 m and a height of 180 cm

Measuring at a distance of 30 meters caused more problems than previous distances. At a sensing height of 180 cm, the dense vegetation caused significant problems. The sensor was unable to pick up the heat signature through the thick layer of clover. Overall, at this distance detection was problematic.

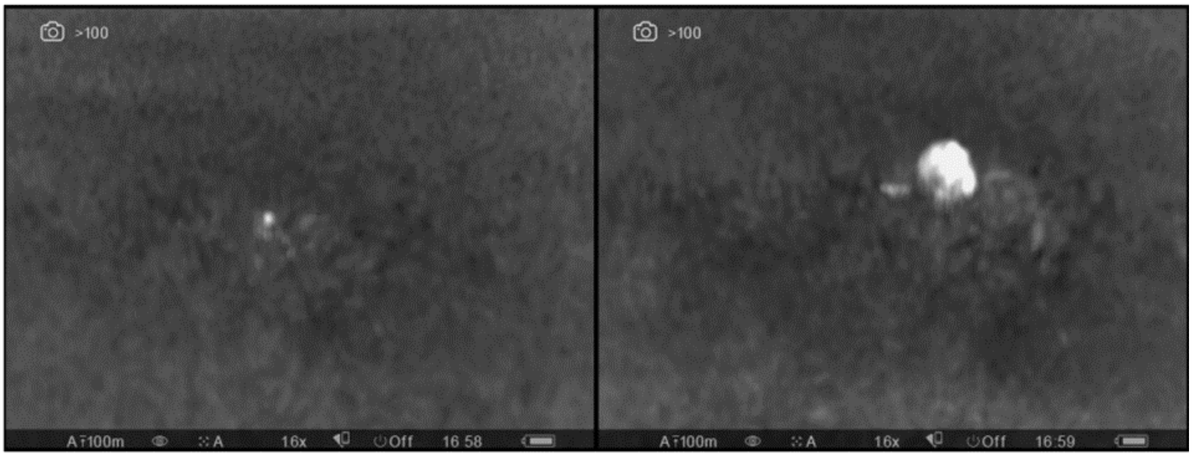

Fig. 4 Thermographic record on the left in a winter wheat (Triticum aestivum) stand at a detection distance of 20 m and a height of 180 cm

Table 1 Results of the animal detection assessment

Height of thermocam placement, cm	Detection distance, m	Crop type	Measurements		Detection success rate, %
			Success	Failed	
180 cm	5	Clovers	30	0	100
		Wheat	30	0	100
	10	Clovers	25	5	83.3
		Wheat	27	3	90
	20	Clovers	16	14	53.3
		Wheat	19	11	63.3
	30	Clovers	7	23	23.3
		Wheat	10	20	33.3

Wheat came out better in the measurements, but the differences were not large compared to clover. At a distance of 10 metres, we had 25 successful measurements in clover. This value represents a success rate of 83.3 per cent. At a distance of 20 metres, our success rate dropped slightly above half, i.e. 53.3 per cent. At a distance of 30 metres, the success rate was only 30%. The results showed that detection at greater distance is unsatisfactory. In thinner vegetation, the results were only marginally better.

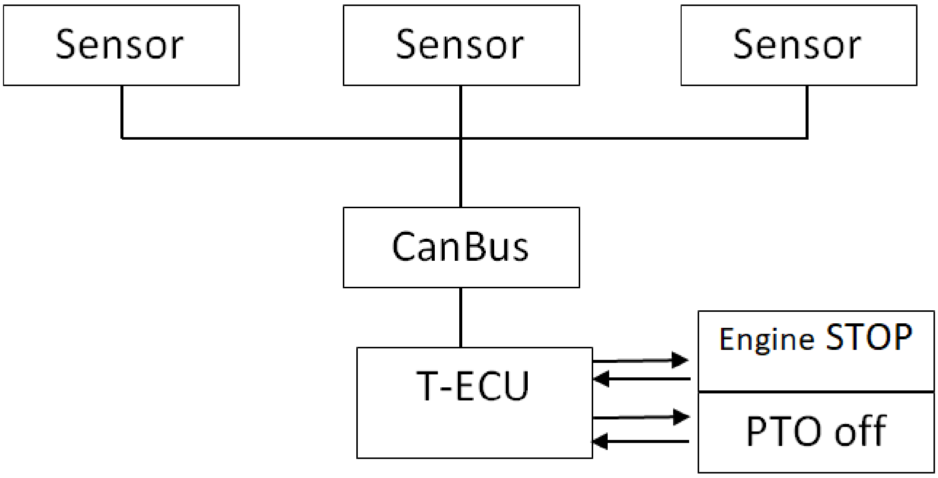

Fig. 5 Controlling the proposed model

On the basis of the obtained results, it is possible to create a model for animals detection, which could be used in field conditions.

CONCLUSION

The results showed that this device is suitable for performing detection and monitoring under certain conditions. Measurements have shown that the optimum distance for taking measurements is between 10 and 20 metres. In the measurements, the height of the placement of the thermal imager proved to be very important. If a higher height is chosen, the detection success rate will be higher. The reliability of the device we investigated also depended on the outside temperature and humidity. The ambient temperature is very important. If the outside temperature is too high and the surface is overheated, so the temperature difference is very small. This problem can be solved by image processing and image analysis. However, we also found that the most appropriate solution would be to use a thermal imaging camera placed on the drone. The obtained results can serve as a basis for the design of a model for automated detection of game during agricultural work, which would allow either automatic stopping of the tractor or sending an early acoustic signal.

ACKNOWLEDGEMENT

This paper was created with financial support of the grant project VEGA no. 1/0102/21 - Reducing chemical loads and degradation of agricultural and forestry soils by selecting appropriate agri-technology with regard to climate change.

This paper was created with financial support of the grant project KEGA no. 016SPU-4/2021 - Implementation of modern educational approaches and tools to enhance creativity and practical skills of graduates with special focus on agricultural and forestry science using.

This publication was supported by the Operational Programme Integrated Infrastructure within the project: Sustainable smart farming systems taking into account the future challenges 313011W112, cofinanced by the European Regional Development Fund.

REFERENCE

[1] Demo, J., (2019). Detection of animals at work with agricultural machinery. [Diploma thesis], Nitra, 2019.

[2] Havlíček, Z. et al., (2007). New trends in environmental protection in livestock breeding conditions. Certified methodology. Brno: Mendel University in Brno, 73s. ISBN 978-807375-120-3.

[3] Kangalov, P., (2013). Methods and diagnostic tools. Ruse: University of Ruse "Angel Kanchev", ISBN: 978-619-90013-3-2

[4] Marada, P., Havránek, F., (2020). Application of rodenticides to control voles and requirements for animal husbandry. Hunting 3: pp.10-13

[5] Marada, P., (2020): Proposal for a new agro-environmental measure - protection of small game. Hunting 2: pp.6-9

[6] Mccollin, D., et al., (2000). The flora of a cultural landscape: Environmental determinants of change revealed using archival sources. Biol. Conserv.92: 249–263, doi:10.1016/S0006-3207(99)00070-1.

[7] Steen, K., et al., (2012). Automatic detection nof animals in mowing operations using thermal cameras. Sensor 12:7587_7597 DOI 10.3390/s120607587.

[8] Weterings, M., et al., (2016). Strong reactive movement response of the medium-sized European hare to elevated predation risk in short vegetation. Anim. Behav.115: 107–114, doi:10.1016/j.anbehav.2016.03.011.

[9] Wrzesień, M., Denisow, B., (2016). The effect of agricultural landscape type on field margin flora in South Eastern Poland. Acta Bot. Croat. 2016, 75, 217–225, doi:10.1515/botcro-2016-0027

CONTACTS

Pavol Findura, Institute of Agricultural Engineering, Transport and Bioenergetics**,** Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: pavol.findura@uniag.sk ***and*** Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: pfindura@fzt.jcu.cz

Petr Bartoš, Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: bartos@fzt.jcu.cz

Hristo Beloev, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg

Miroslav Prístavka, Institute of Design and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: miroslav.pristavka@uniag.sk

Zbyněk Havelka Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: zhavelka@fzt.jcu.cz

Radim Kuneš, Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: kunesr@fzt.jcu.cz

Luboš Smutný, Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: smutny@fzt.jcu.cz

Pavel Olšan, Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, Studentska 1668,370 05 České Budějovice, Czech Republic, e-mail: olsan@fzt.jcu.cz

Erik Lavrík, Institute of Agricultural Engineering, Transport and Bioenergetics**,** Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xlavrik@uniag.sk