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Low-cost infrared sensor for wildlife detection in vegetation

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Abstract

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The protection of wild animals from mutilation or being killed during haymaking is still a serious problem connected with high working speeds and widths of modern harvesting machines. That is why the main aim of this study was to test low-cost, high-speed and low-noise infrared array sensor Melexis MLX90621 for the application of wildlife detection with the potential to be used in front of the mower equipment. The tests with two different crops with or without a hidden dog were made. Results showed that the sensor is able to detect an animal hidden in the crop with very high probability. Nevertheless, direct sunlight conditions can cause the problems when using infrared technology. A simultaneous use of other sensors working on different principle than infrared technology can be thus recommended.

Keywords: haymaking; wild animals' protection; internet protocol camera; infrared array sensor

Protection of livestock and their welfare achieved really high grade in relation to intensive economic human activities. Yet, in the case of wild species, their protection is solved more in general terms without affirmative impact for animal welfare. A clear example of such violence and disregard for the rules of proper farming is the first spring haymaking. Especially for roe deer neonates it is probably the most important mortality factor.

According to Jarnemo (2002), in the south-central Sweden during 1997–1999 fawn mortality caused by mowing was estimated at 25–44% of the yearly recruitment. It is caused by roe deer fawn natural instinct to stay lay low and still in the vegetation, which increases their risk of being killed or injured by agricultural machinery (Kittler 1979). Although a great importance of mortality caused by harvesting devices had been highlighted by several authors since the 1970's, it started to receive more attention in the past decade (Gaillard et al. 1998; Jarnemo 2004; Jarnemo, Liberg 2005). Death of fawns from agricultural machines is severe in most cases, with frequent cases of cut feet and subsequent bleeding. Other species that are in danger during pasture moving are nesting birds. Ground-nesting females that are incubating eggs are extremely reluctant to leave their nests. Even nests escaped from damage by mower machinery are often attacked by predators (Green 1998).

An effort to develop a system to be able to startle wildlife and to be placed directly on harvesting machines was evident already in the 1980´s. For example, Junker (1986) patented an animal-protection device based on the mechanical principle.

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Therefore, a current trend is to develop a system that can provide wildlife detection in front of the mower machine. For this purposes infrared technologies or Doppler radar can be used. It has been revealed that under certain circumstances the Doppler radar can provide detection of living objects (Israel et al. 2010). It was confirmed that the most negative impact that decreases detection is the vegetation density and moisture content. Vegetation with higher moisture can simply reflect the signal emitted from the radar that makes detection in dense vegetation or in the morning time when vegetation is on dew and detection is not possible. Apparently, for better efficiency of detection it is necessary to use the combination of the Doppler radar with another thermal sensor witch can ensure an increase of the detection efficiency.

The device that can be used for these purposes are thermal camera or sensor. Experiments that confirm successful utilization of thermal cameras for living objects, exactly human body, have already been made (Rudol, Doherty 2008). Israel (2014) used an unmanned aerial vehicle (drone) equipped with thermal and optical camera to detect wild animals hidden in a site before harvesting. Similar method was used also by Jørgensen et al. (2015).

In the case of the application of thermal cameras on the mower equipment for wildlife detection some problems, such as poor image focus, have been discovered. In this experiment, thermal cameras were mounted on a side of the mower unit (mounted on tractor); however, high working speed (15 km/h), camera placement low above vegetation and vibrations caused by mower unit resulted in bad image quality (Israel et al. 2010). Unfortunately, a big disadvantage of thermal cameras was also their high price.

The infrared sensor can be a perspective device that can provide detection of animals. There are some successful applications of infrared sensors for wildlife detection that have been patented already in 1991 and 1995 (Diethl et al. 1991; Swenson, Klangeryd 1995). Low-cost thermal sensors in combination with other sensors would significantly reduce the total cost of the final device, allowing better real-life application.

That is why the main purpose of this study is to test low-cost, high-speed and low-noise infrared sensor Melexis MLX90621 for the application of wildlife detection with the potential to be used in front of the mower equipment.

MATERIAL AND METHODS

Experiments for this research were carried out in the area of the CULS campus on May 5, 2016. It was a sunny day with the maximum temperature of 18°C. The main aim of this experiment was to detect an animal hidden in vegetation. New infrared array sensor from the Melexis Co. (Belgium), type MLX90621 was used for these purposes. This is relatively fast and low-cost sensor with the price of about 100 EUR. The main parameters of the Melexis sensor are: resolution 4 × 16, field of view of 60° × 15°, adjustable frame rate of 0.5–512 Hz and I^2C communication interface (Fig. 1). A dog of the Bavarian Mountain Hound breed was chosen as an experimental animal for this trial. The research was carried with two types of vegetation. The first sample of vegetation was composed mainly of young shoots of honeysuckle (*Lonicera*). The second sample consisted mainly of quack grass (*Elytrigia repens*).

The main arrangement of the equipment for these experiments was as follows. The linear drive frame was placed above vegetation. On this frame infrared sensor was mounted moving to each side on linear drive frame with defined speed (0.05 m/s), that ensures gradual scanning of the area under frame. The sensor was moved at the height of 1 m above the surface and overall scanned surface dimension was 1.2 × 1.5 m. Reference images from the Internet protocol camera mounted near the infrared sensor on linear drive were acquired during all measurements. A detailed arrangement of the measuring workplace can be seen in Fig. 2.

Infrared sensor was connected with the evaluation board EVB90621 (Melexis Co., Belgium) that was connected by USB cable with computer to save

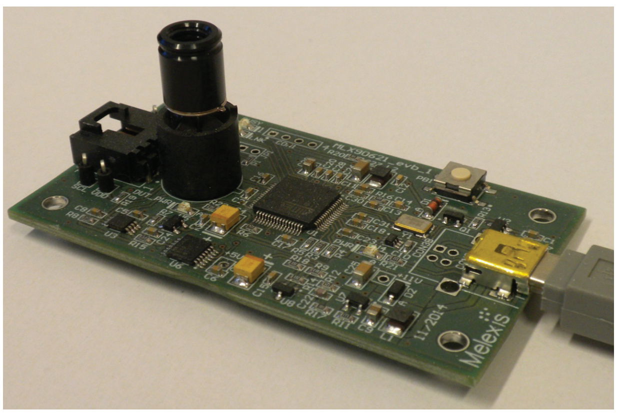

Fig. 1. Infrared array sensor from the Melexis Co., type MLX90621 connected with an evaluation board EVB90621

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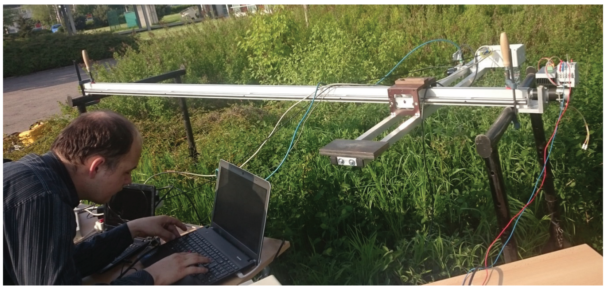

Fig. 2. Detailed arrangement of the measuring workplace with linear drive above vegetation infrared sensor and Internet protocol camera were connected by USB cables with computer

the obtained data. On both types of vegetation four measurements were made – two with dog and two without it (eight measurements in total). The frame rate was set to 30 Hz.

The images with dog were compared to the images without dog with the aim to evaluate the function of infrared sensors. Ten seconds (10 s) intervals corresponding to 0.5 m distance driven by linear drive were evaluated for each measurement made. This length was chosen with regard to the size of the crop in which the dog was found. 300 images were evaluated from each measurement. Two parameters were calculated from each image, the mean temperature t_a and the mean temperature from four highest temperatures t_{a4} (each image was composed from 64 temperatures measured by the infrared sensor). These calculated values were then used for data analyses due to low sensor resolution. Arithmetic means and standard deviations were then calculated from these values for the next evaluation.

The data evaluation was performed using the Python programming language, version 2.7.

RESULTS AND DISCUSSION

Images from the first measurement can be seen in Fig. 3. Fig. 3a represents the image of honeysuckle crop with hidden dog. Dog visibility in the Internet protocol camera optical spectrum was very bad in this case, as it is clear from Fig. 3a; the parts of dog's dark fur are obscured. Figs 3b and 3c are the thermal images from the infrared sensor. Fig. 3b shows the area with a hidden dog and Fig. 3c without it. It is possible to observe some areas with the temperature exceeding 20°C in Fig. 3b. These areas corresponded to the thermal radiation which penetrated the vegetation from the surface of the dog. In contrary, similar areas cannot be observed in Fig. 3c. It is also clear that the scanned surface without dog had a considerably lower temperature (about 18°C).

The results of individual measurements' statistical comparison are shown in Fig. 4. Numbers from 1 to 4 indicate measurement number and letters indicate whether the measurement was made with a hidden dog (A) or without a dog (B). The mean

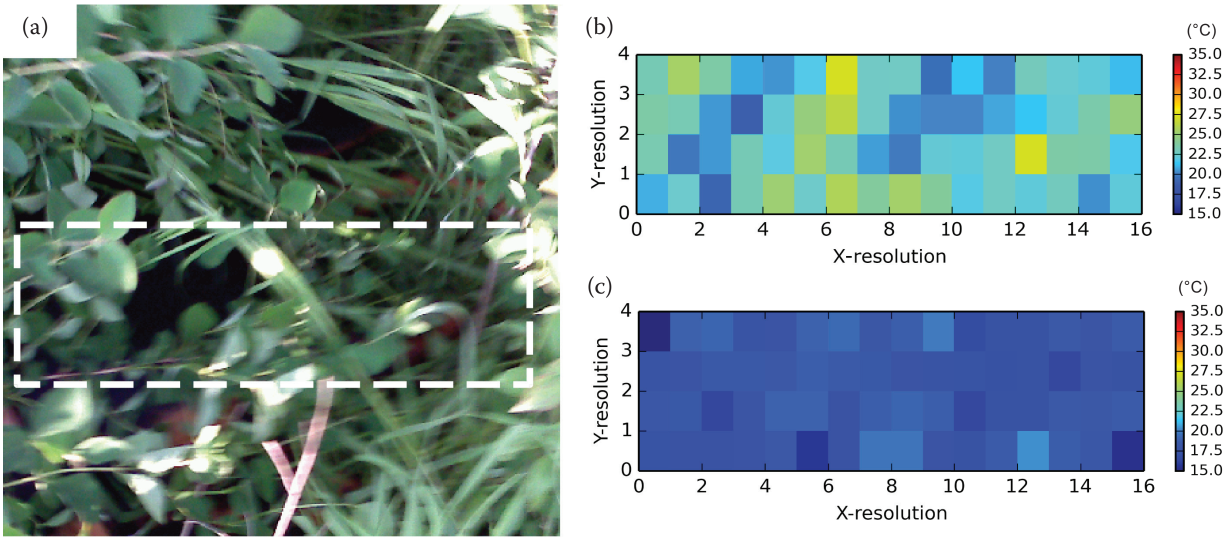

Fig. 3. Image of a dog hidden in the vegetation (a) composed mainly of honeysuckle taken with the Internet protocol camera in optical spectrum. White rectangle highlighted in dashed line corresponds to the evaluated scan of infrared sensor. Thermal image taken with infrared sensor (b) from the area highlighted in (a) in the case when the dog was hidden in the crop. Thermal image of the same crop (c) taken with infrared sensor without dog

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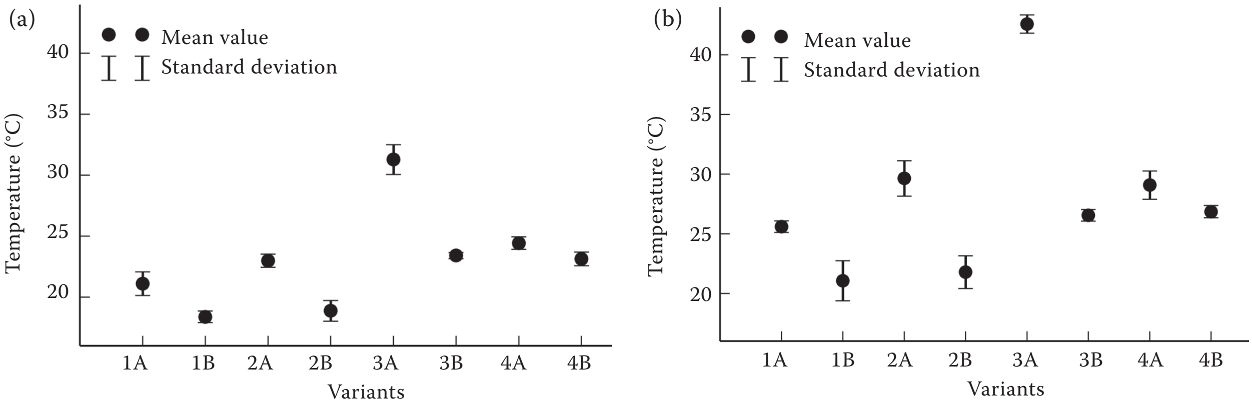

Fig. 4. Statistical comparison of the tested treatments: (a) the mean temperature from all measured values and (b) the mean temperature from four highest temperatures. The mean temperature and its standard deviations are charted; 1–4 – measurement number; A – measurement was made with a hidden dog; B – measurement without a hidden dog

temperature t_a and its standard deviations are charted in the graph in Fig. 4a and the mean temperature t_{a4} and its standard deviations are charted in the graph in Fig. 4b. The differences between the experiment with (A) and without (B) a dog were higher than the standard deviations in all observed cases. Based on these results it can be stated that statistically significant differences were found in all the observed cases.

The measurements marked 1 and 2 were carried out in the honeysuckle crop. The dog was hidden in the crop in a similar way as illustrated in Fig. 3. Crop temperature corresponded with surrounding outdoor temperature and the difference between thermal images with a hidden dog (A) and without a dog (B) was approximately 3°C and 5–7°C for temperatures t_a and t_{a4}, respectively.

The measurements marked 3 and 4 were made in the quack grass crop. In the case of 3A measurement, the dog was not covered by the crop. That is why a great difference of the measured temperatures was observed for variants 3A and 3B. In the contrary, during the last measurement (4) the dog was well covered by the crop and the observed difference between temperatures was considerably smaller in this case.

The main difference between the measurements with the first and second evaluated crop was, among others, that in the second case (variants 3 and 4) the crop was exposed to direct sunlight. Relatively high temperatures (higher than ambient air temperature) obtained in those measurements can be explained by this fact. This behaviour may complicate the use of infrared technology for wild animals' detection in the crop and this phenomenon must always be taken into account. Maybe, the use of multiple sensors operating on different principles can be recommended. This idea was supported also by Israel et al. 2010.

The comparison of t_a and t_{a4} temperatures showed that probably the use of t_{a4} temperature (mean temperature averaged from four highest temperatures) is promising for our purposes. It follows from the comparison of the graphs provided in Fig. 4. The differences between the temperatures t_{a4} for the measurements with and without a dog were always twice as high in comparison with the differences determined between t_a temperatures. It is caused by the fact that the detected dog was taken usually just as a part of the infrared sensor visual image. On the other hand, mean temperature t_a is calculated automatically by the sensor itself. The advantage of using this temperature can be that the electronic circuit necessary for signal processing could be simpler.

In comparison with infrared cameras used by Israel et al. (2010) our infrared camera was low-cost and faster. It can be assumed that due the rapid development of this technology, infrared cameras price will continue to fall and its parameters will improve. This fact encourages further research in this area. However, the speed of our camera movement was significantly lower than the one used by the authors above.

CONCLUSION

New infrared array sensor Melexis MLX90621 was tested for the purpose of an animal hidden in

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crop detection. On the basis of our measurements it can be concluded that the use of such a sensor can be an interesting and cheap mean for wild animals' detection in front of the grass harvesting machinery. During our tests, the animal (dog) was always successfully detected, even in the case of partial covering by surrounding vegetation. The future testing of the sensor in the field conditions can be recommended. The use of infrared sensor is limited in terms of direct sunlight conditions. The combination with other sensor types can be recommended in order to eliminate this disadvantage.

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