REAL-TIME BIRD DETECTION AND COLLISION RISK CONTROL IN WIND FARMS

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Real-time bird detection and risk control in wind farms

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SUMMARY

Bird collisions in wind turbines are a fact and will be on the rise with the increase in the number of wind farms around the world. Existing bird control tools like radar, HD camera or human visual detections have a number of drawbacks each and have not been able to prove their efficiency up to the standards of wildlife protection national organizations and supranational groups. Precision and range of thermal imaging combined with appropriate software provide for likely the most reliable bird and bat detection capability today. Detection recordings present a way of objectively analyzing the performance and accuracy, while custom-designed sounds invoking acoustic startle reflex deter virtually all avian species already at 400+ meters without allowing for habituation and minimizing the need for WTG stoppage, thus maximizing wind farms' production efficiency.

"Do we value short-term advantages above the welfare of the Earth? Or will we think on longer time scales, with concern for our children and our grandchildren, to understand and protect the complex life-support systems of our planet? The Earth is a tiny and fragile world. It needs to be cherished.

Carl Sagan, Astronomer

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1. INTRODUCTION

The constant expansion of wind energy requires fast and effective innovative solutions for bird detection and collision risk mitigation. This is true for both currently operational and under-construction wind farms. Different bird species are at different risks of collision, with large thermal soarers such as eagles (Aquila), pelicans (Pelecanus) and vultures (Gypinae & Gypaetinae) being some of the most likely victims [1]. Often, wind parks are located in regions of high biodiversity, with turbines being built in valleys acting as natural wind tunnels, increasing turbines' efficiency [2]. These wind tunnels, however, are also used by various birds in the area, creating a funnel effect by connecting both metapopulations of locally breeding species in addition to migratory ones [3]. Likewise, when turbines are built on mountain ridges wind generated by orographic uplift is utilized by both turbines and soaring birds. One solution aimed at reducing mortality risk from wind turbines is the installation of camera-based detection systems monitoring the surrounding area for bird activity [4]. Following a bird detection, the system may use acoustic emittance to deter it from the WTG zone or stop the turbine as a last-resort measure for preventing collision. As the results below show, the system is applicable to detections of bats as well. This study assessed the efficiency of one such system installed in the high-avian-biodiversity NATURA 2000-protected Kaliakra region of NE Bulgaria (Black Sea coast). Currently, the main methods for bird registration, that meet the standards of international wildlife organizations and the European Commission, are radars day cameras and human visual detections [5].

We aimed to assess the precision of a novel tool: the thermal imaging camera, combined with appropriate detection software:

a) We analyzed the camera's reliability as bird and bat detection tool.
b) The system's detection recordings were assessed as a way of objectively analyzing the performance and accuracy of the detected objects.
c) The capacity of such a system to minimize the need for WTG stoppage, thus maximizing wind farms' production, efficiency was evaluated.

2. METHODS

2.1. EXPERIMENTAL DESIGN

We analyzed the detection rate efficiency of a thermal imaging camera-based bird collision avoidance system installed on an operating wind turbine and capable of autonomous detection at 500+ meters with precise azimuth. The experiment was carried out in NE Bulgaria during the months of August and October 2020, within the period of autumn bird migration (Figure 1, Figure 2).

Figure 1. The position within the Balkan peninsula where the study took place, with Volacom's BCAS highlighted in a yellow pin.

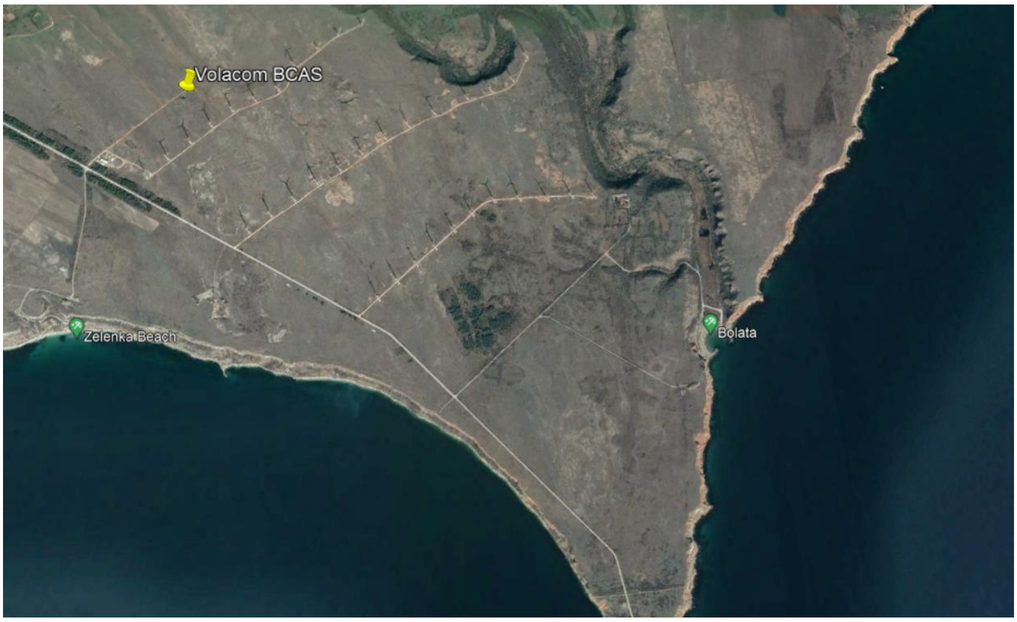

Figure 2. The study site, with Volacom's BCAS highlighted in a yellow pin. The Black Sea coast is visible alongside multiple rows of wind turbine generators.

The system was equipped with a custom-built detection software providing live picture and video logs of each recorded detection. Human observations were conducted every day by ornithologists with visual detections recorded in a log book for comparison purposes after. After the end of the experiment the video recordings were analyzed individually to filter bird and bat detections from others. The results were then compared to ornithologists' log books records (Figure 3).

Figure 3. Volacom's BCAS, installed in the Kaliakra region, NE Bulgaria.

The thermal imaging camera had the following technical specifications.

- Vertical field of view: 26 °
- Horizontal field of view per frame: 32 °
- Total horizontal field of view: 192 °

Detection ranges:

- 60 cm wingspan: up to 350 m
- 100 cm wingspan: up to 600 m
- 150 cm wingspan: up to 1050 m

The experiment was carried out at an operating wind turbine park in NE Bulgaria during the months of August and October 2020, within the period of autumn bird migration. The system was equipped with a custom-built detection software providing live picture and video logs of each recorded detection. After the end of the experiment the video recordings were analyzed individually in order to assess the validity of each detection.

Each detection, recorded by the bird collision avoidance system (BCAS), was stored on a hard drive and was available for review as shown (Figure 4). The exact time and date of the detections are visible. Multiple objects were recorded as such.

Figure 4. Bird detections as seen by the Volacom thermal software user interface.

3. RESULTS

3.1. DETECTION RATE

All data records were analyzed individually by two ornithologists to arrive at accurate and objective results. True positive detections by the thermal camera-based system and software for August 2020 were 805 birds and bats out of 965 total detections (83.1% accuracy) (Figure 6). False positive detections were mainly insects (7%), turbine blades (3%), picture distortion by vibrations (2%) (Figure 5). True positives for October 2020 were 780 birds out of 850 detections (91.8% accuracy). Insects were comparatively less due to colder weather (4.7%). Correlation of system detections vs actual human detections was strong although limitations of human eyesight made it difficult to quantify the results. Specific sound emittance had persistent efficiency in deterring birds away from WTGs.

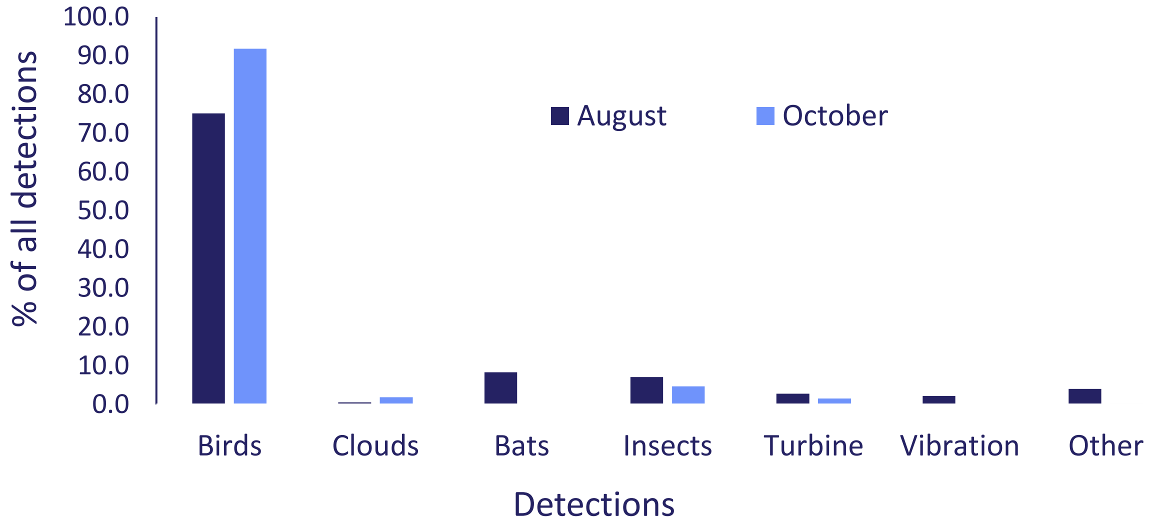

Figure 5. Structure of all detections for months August and October 2020.

Overall, the rates of true positive detections were 83.1% and 91.8% respectively (Figure 6).

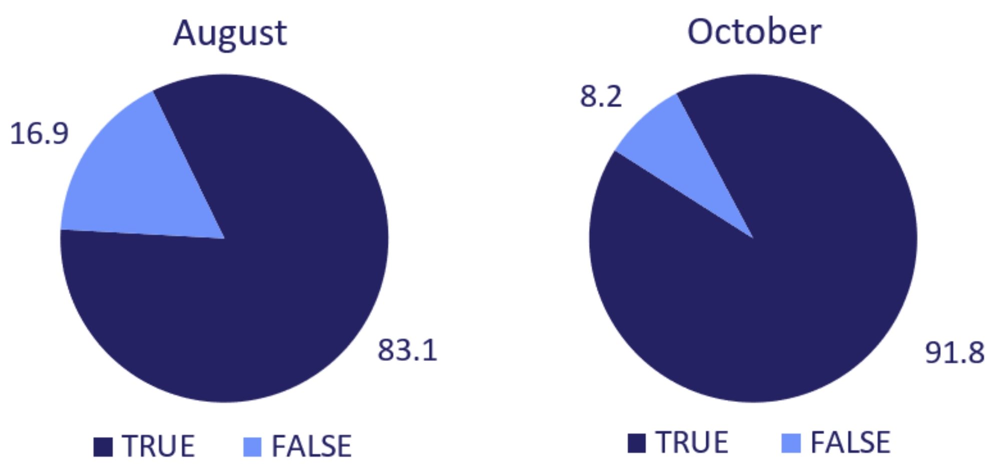

Figure 6. Percentages of true and false detections for months August and October 2020.

4. DISCISSION

The difference between the true positive detection rates in August (83.1) and October (91.8) occurred due to the calibration of the system (Figure 6). Calibration involves activities such as masking (marking moving objects like WTGs and trees), positioning the horizontal and vertical fields of view of the camera (HFOV and VFOV) to make better use of the camera's capabilities, taking into consideration the local topography [6]. Throughout the literature, multiple assessments of various bird detection techniques and technologies have been made [7] [8]. Currently, the two most popular methods are radar and visual observations. Thermal vision is comparatively new technology, and its use in bird monitoring and detection is completely novel.

Each method has its pros and cons and thy are important to consider when assessing discussing the "best" one. Radar generally is able to detect around two-to-three times the number of birds as visual observations and is able to detect birds at night, which is critical since high-risk bird species like waders, ducks and geese are both nocturnal and diurnal migrants [9]. Furthermore, cuckoos, flycatchers, warblers, vireos, thrushes, orioles and sparrows migrate exclusively at night, making nocturnal detection a requirement for bird strike mitigation technologies at wind farms [10]. The detection distances of radar are another plus, being able to detect geese at ~ 2km, provided favourable weather conditions. At night, the only option for human observations are moon-watching surveys and sonogram analysis, which are both highly specialized and require highly trained experts, whose labour is highly expensive, in addition to working night shifts [11]. Furthermore, radar often produces a large amount of "noise", triggering false detections. Last but not least it is important to take into consideration the price of radar technology, which often outweighs both human labour and thermal-based cameras [12]. Day cameras are often overlooked since their detection distance rarely exceeds 300 meters and they are completely inefficient during the night or bad weather.

Thermal vision tends to combine the benefits of pros of radar (detection distance, nocturnal efficiency) and day cameras (video records) while bypassing the limitations. Taking into consideration that thermal rarely manages to detect objects are over 1.5 km (depending on size of course) the benefit from a video log which can then be analyzed and stored for later viewing is notable. For a wind park, a combination of all available technologies and methods would be the best solution for bird risk mitigation, however in reality limited budgets do not tend to allow of the best possible solution.

5. CONCLUSSION

Globally, bird collisions into with man-made structures cost the lives of millions of birds annually. In the past this added mortality has largely been considered insignificant on population level but research in recent years shows selected species being particularly vulnerable, especially in protected wildlife areas. The BCAS system successfully generated 1582 true positive detections. Considering the camera's field of view, we consider this to be a correct estimate of bird activity in the area. The analysis of all 1815 detections revealed that the system had a success rate (true positive detections) of 83.1% for August and 91.8% for October. In our opinion the high sensitivity of the thermal sensor, combined with the high success rate of the detection algorithm: 87.5% (two-month average) meets the requirements for use as a bird control tool at wind farms. High-precision weather conditions-independent imaging devices like thermal cameras with sophisticated detection and automation software built-in provide the necessary tool for detecting likely every bird in the area. Specially developed acoustic deterrence signals can mitigate the collision risk down to single-digit percentages without causing physical harm or stress to avian species. Operation of last-resort WTG stop control modules can be minimized and automated.

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