Development and first results of a bird impact detection system for wind turbines

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1. Introduction

In the Netherlands the Dutch government has set a very ambitious target for offshore wind energy of 6000 megawatt in 2020. Environmental impact of wind energy plays an important role in the public acceptance that also influences the decision-making processes. Since the introduction of wind energy, there is a concern that turbines would cause harm to birds. A lot of studies about nuisance to birds from wind turbines onshore are executed in the last decade. Still many questions are left related to the development of wind energy offshore. In most countries, wildlife protection organisations and environmental groups follow the development of offshore wind energy. In order to get more information about birds at sea, new tools and methods are needed to increase knowledge in this field. The lack of appropriate tools and information evoked a lot of negative publicity on wind energy and reduced the opportunities to realise projects.

2. Objectives of the work

Environmental issues play an import role by implementing wind turbines offshore. An important item is the fear of bird collisions. Existing knowledge is mainly based on studies at onshore sites with relative small wind turbines. An inventory on bird's detection systems and methods shows a lack of appropriate methodologies to study bird victims caused by wind turbines [1]. That's one of the reasons why ECN started the development of an automatic bird collision detecting system called WT-Bird [3,4].The PC based system must be able to identify bird collisions and determine the species as well.

3. Approach

The applied method is noise monitoring and video images storage. In case of special events: *the sound of a collision against the tower, nacelle or rotor,* the noise and a video clip of the event (some seconds before and after the event) are saved at disk. The noise and the video clip must answer the question; what kind of bird was killed.
The system developed is based on a PC computer, so that it is relatively cheap and it will be well housed, covered and build for offshore conditions. The software identifies the sound of a bird impact out of the noise of a turning and idling wind turbines. This means, "learning" the computer the normal sounds of a turbine like yawing and pitch control.
For this purpose, on-line data analysis is necessary. Several experiments were carried out for a step by step improvement and development of a reliable system.
Ornithologist can study recorded video clips and sounds to determine the species and possible false alarms can be eliminated.

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3.1. The WT-Bird system

The system consists the following parts, each with its own functionality:

1. Sound measurement and noise analysis
2. Camera registration
3. Analysis unit.

Below, you can find a short description of the first two parts of the system.

3.1.1 Sound measurement and noise analysis

The sound measurement and noise analysis is used for two tasks:

- Noise registration.
- A trigger to distinguish between abnormal noise (potential bird collision) and normal characteristic wind turbine noise.

Continuously, the sound of the turbine is measured. In real time this sound measurement is analysed using noise analysis techniques, like the well-known FFT technique (Fast Fourier Transform). When an abnormal sound, relative to normal operation, yawing, start-stop actions, has been detected, a bird collision could have been taken place and this recording is stored. The sound recordings are taken inside the turbine tower. It should be clear that each type of wind turbine and even each wind turbine itself have a different sound characteristic. Therefore, the system is adjusted for each specific turbine by learning the specific background noise. Figure 1 shows the simplified set-up of the system. Two microphones, mic 1 and mic 2, are used for sound registration and noise analysis. Note figure 1.b) shows optional camera positions and the lower position can be directed to other wind turbines in the wind farm.

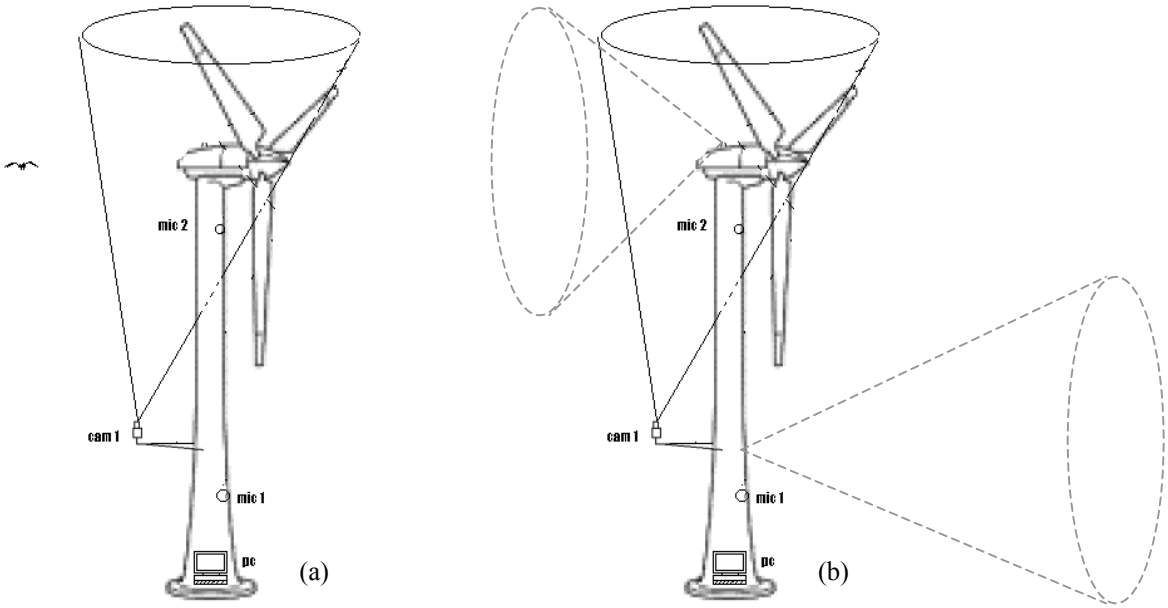

Fig. 1: Schematic overview of the system's sensors, b) optional camera positions

Note that although the first set-up of the system is for detecting birds the system should be capable to perform other duties, like lightning impact detection, overall wind farm monitoring etc. etc.

3.1.2 Camera registration

As mentioned earlier the detection system has two goals: one to register bird impacts and second to classify the bird, or to determine the specific species of a bird after the detection of a collision. The second goal is achieved using camera registration.

Questions to be answered in this respect are: where to the birds collide (rotor, nacelle or tower? And at which height?) , do birds collide during the day or at night and how many frames and with what resolution video registration has to be carried out to recognise a bird, and at what distance from the camera can a bird still be recognised?

At the moment the system is operating with one camera, located at the bottom of the tower, which monitors the mast and the rotor. Although more cameras are foreseen to register the birds, which collide with the turbine mast, nacelle or rotor the first systems are equipped with just one camera. Figure 2 gives an view of the rotor made with the camera.

Fig. 2: Camera view of the rotor of a NedWind 30 wind turbine at the ECN test facility

The camera registrations are only stored when the sound registration detects an abnormality, like a bird collision. So the registration will be triggered by the sound analysis and images of a short time before the trigger and after the trigger will be stored and enabling us to classify the flying bird, before collision.

3.1.3 Analysis unit

Using a processing unit will do the sound registration, sound analysis and web cam registration. In figure 1 the unit is installed at the bottom of the tower.

The advantages of the WT-Bird system:

- Using these sound and camera registrations, a biologist can recognise the species of the collided bird. The biologist doesn't have to go through several hours of sound and video, because only the images and sound recording will be stored when a probable impact is detected.
- The system doesn't need any instrumentation at the rotor. There is no modification of the wind turbine itself. The instrumentation consists of the cameras and the microphones. The microphones inside the mast are glued against the mast.

The camera itself is placed in a special cabinet so it can operate in harsh conditions and is also somewhat protected for vandals. Figure 3 shows the protective cabinet of the camera.

Fig. 3: Camera housing of the camera with mirror.

3.2 Field experiments

To determine if the system works according to the functional specifications some first experiments are being executed to retrieve information about the possibilities to detect bird collisions. These experiments consist of two parts, a simulated test and a long-term test.

The following experiments were executed as a proof of principle:

1. Simulated bird collisions against the tower of a operating wind turbine;
2. Simulated bird collisions against the rotating rotor of a wind turbine;
3. Presenting several different turbine sounds to the bird detection system.

3.2.1 Simulated bird collisions against the tower of an operating wind turbine

These experiments were executed to prove the principle of detecting the collision of birds against a wind turbine. To simulate a bird, small bags of sand with different

weights, to simulate different species of birds were thrown against the tower of a wind turbine. Figure 4 shows some examples.

Fig. 4: Sand bags used to simulate birds

An example of the sound measured inside the turbine tower at the moment of simulation of a bird collision is shown in figure 5. This sound registration clearly shows that these collisions are detected.

3.2.2 Simulated bird collisions against a rotating rotor of a wind turbine

A second experiment was carried out to investigate the possibilities to detect a bird collision against the wind turbine rotor with microphones placed against the turbine tower. In this case birds were simulated using tennis balls and a tennis ball-shooting machine.

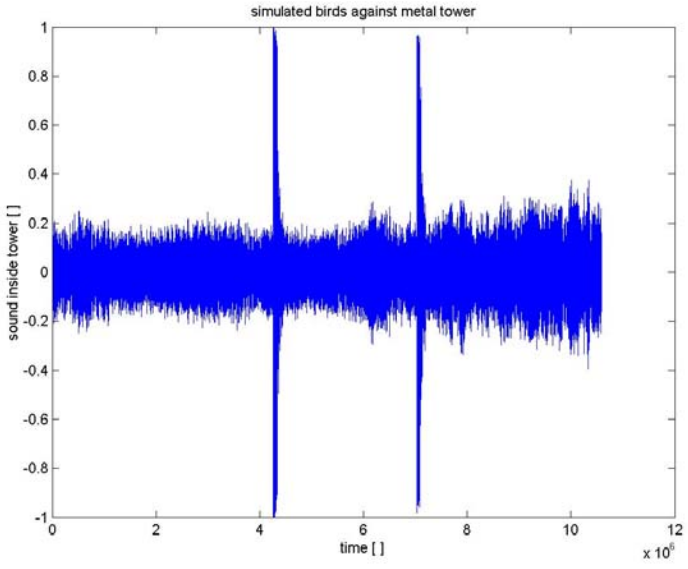

Fig. 5: Sound registration during simulated bird collision against a wind turbine mast.

In figure 6 the tennis ball shooting machine and the turbine are shown. After some practice the blades were hit.

Fig. 6: Tennis ball machine used to simulate bird collisions against the blades

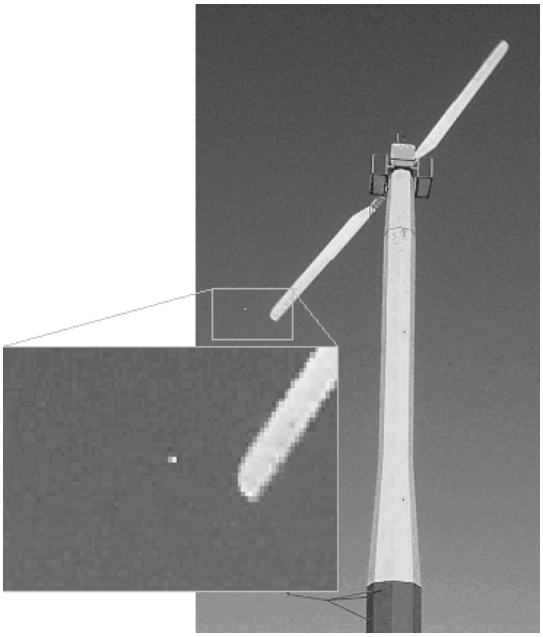

Fig. 7: Tennis ball flies against the rotor blade; the tennis ball is enlarged

A hit against the rotor blade is shown in figure 7.

Figure 8 shows the sound registration of a tennis ball hitting one of the blades. Although the impacts are less clear as in figure 5 still we can detect the impacts. The background noise level (normal noise during operation) of the turbine shown in figure 8 has a high level, much higher then recorded in other turbines.

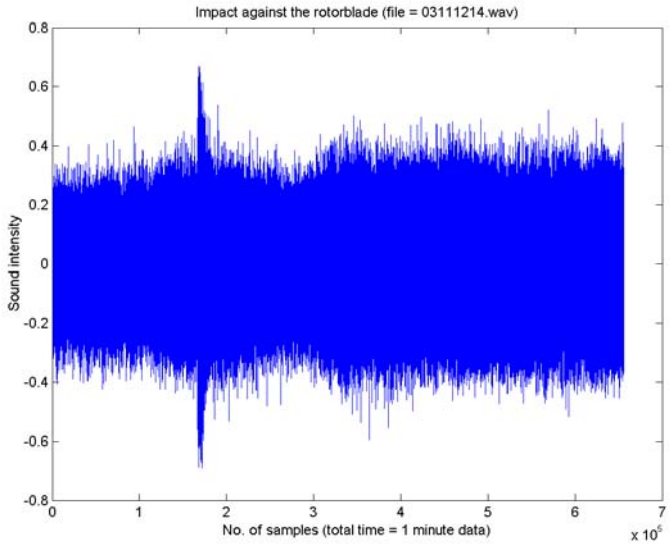

Fig. 8: Sound registration of two tennis balls against the rotor.

3.3. First applications

Based on the results of the proof of principle two systems were build and placed on two locations in the Netherlands. One system is placed in a solitaire Vestas 225 kW wind turbine in the city of Den Helder while the other system is placed at the roof of a control building at the foot of a 1.65 MW Vestas wind turbine of the onshore wind farm Waardtocht in the north part of the province North Holland.

The system in Den Helder has been operating during two months and so far no bird collision is detected. Also no dead birds were found during regularly visually inspections at the spot. The second system is operating is running for one month and also did not detected any bird collisions. On a regular basis inspections around the feet of the wind turbines are carried out in search for birds victims.

Fig. 9: Location of first application WT-Bird system

To check if the system operates well on a regular basis artificial impacts are imposed on the wind turbine. These impacts are always detected and the results are written to the hard discs of the system.

4. Scientific innovation & relevance

The presented system is unique because it can provide a real indication of the number of bird victims caused by wind turbines and it is not expensive. Project developers, environmental organizations and policy makers can take decisions based on actual numbers of victims. The described approach can also be used for determining other monitoring aspects like condition monitoring and lighting indication.

5 – Results & Conclusions

ECN has developed a bird collision recorder, which detects and registers bird collisions with wind turbines. Experiments with simulated bird collisions show that the event can be heard with by microphones, so detected, and registered. A video clip of the event can be used to identify the species. At the moment two systems are being installed and running satisfactorily at two different sites. Both systems haven't recorded any bird collision and also no birds have been found in the vicinity of the wind turbines.

The bird collision recorder has the following features:

- the system runs continuously and records collisions even at night with its infrared camera;
- only collisions are recorded, a flock of birds passing by without colliding will not be detected;
- the system does not only detect the number of collisions, the registration of sound and images also provides information on the species;
- data can be obtained remotely, and analysed efficiently;
- easy mounting on the turbine, no special adaptations are needed;
- the system is low cost, robust, and reliable and operates under harsh conditions like offshore.

The principle of detecting events by means of noise and sound is further being investigated and developed in the context of research on operation, maintenance, and monitoring of offshore wind farms. Applications, which are currently under development, such as:

- recording of lightning strikes and the impact spots in offshore wind farms which will drastically limit the number of inspection visits after a thunderstorm has passed an offshore wind farm;
- drifters and containers in an offshore wind farm can be monitored and the incidents can be recorded;
- accidents with the wind turbine itself or the turbines in the farm can be recorded.
- ship en fish (harbour porpoise) movements around a wind farm.

6. Acknowledgement

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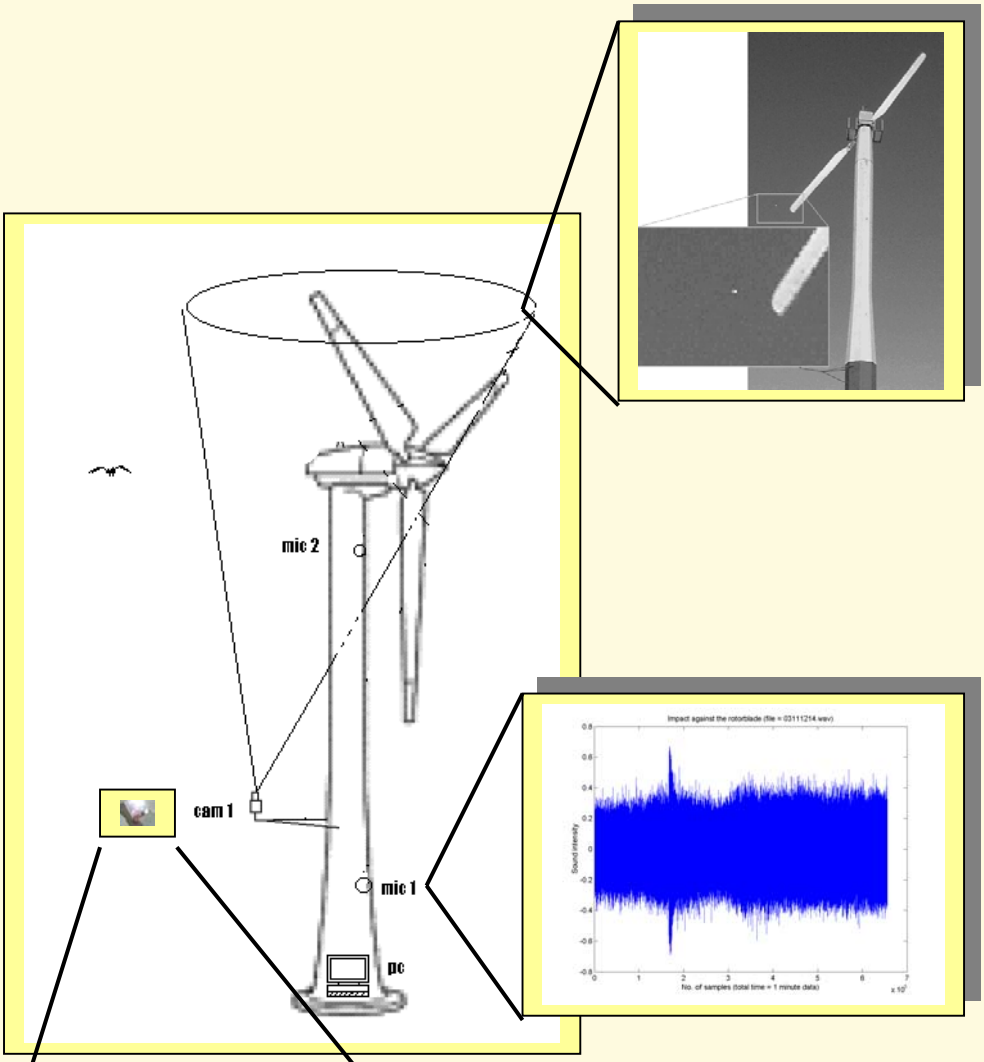

Background

The large-scale implementation of wind energy is hampered to a large extent by the unknown effects that wind turbines may have on the environment. The collision of birds with turbines is a point of great concern. In environmental impact studies, estimates are made of the number of birds killed. After the wind farm has been taken in operation, again investigations have to be carried out to verify the estimations.

WT-Bird system

ECN has developed a low cost, robust and reliable method for detecting bird collisions. Microphones detect the impact of a bird flying against the turbine, a digital camera will record the event and store it on a hard disk. Periodically, operators and environmental researchers can obtain the images and sounds of the recorded events and determine which type of bird has collided.

WT-Bird features

- the system runs continuously and records collisions even at night with its infrared camera;
- only collisions are recorded, a flock of birds passing by without colliding will not be detected;
- the system does not only detect the number of collisions, the registration of sound and images provides information on species;
- data can be obtained remotely, and analysed efficiently;
- easy mounting on the turbine, no special adaptations are needed;
- the system is low cost, robust, and reliable and operates under harsh conditions like offshore

More information

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