WT-BIRD
A NOVEL BIRD IMPACT DETECTION SYSTEM

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Summary

An important implementation issue for wind farms is the risk of bird collision. A lot of the existing knowledge on birds and wind energy is based on studies at onshore sites. With respect to wind energy implementation especially offshore, more information about the environmental impact is needed. Several countries carrying out environmental base line studies focused on offshore wind farm sites. Monitoring wildlife is very labour intensive. That's why ECN develops a computer based efficient environmental monitoring tool.

The aim is to develop, demonstrate and evaluate a noise monitoring system, which identifies bird impacts and also indicates the species. The system must be relatively inexpensive, robust and applicable for offshore conditions. The system identifies bird impacts by noise measurements and a camera identifies the specific species. The system can also distinguish between turbine specific sounds and a real collision against tower, nacelle and rotor.

The WT-Bird detection system built by ECN appears to be a very promising way to detect bird collisions against wind turbines. The first experimental results are good. This way of detecting the collisions of birds can be very useful for the future implementation of offshore wind farms.

1. Introduction

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 special related to the new development of wind energy offshore. In most countries wildlife protection organisations and environmental groups follow the developments of offshore wind energy. In order to get more information about birds at sea, new tools and methods are needed to reduce the uncertainties related to birds at sea. The lack of appropriate tools and information evoked a lot of negative publicity on wind energy and reduced the opportunities to realise projects.
An inventory on birds 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 detecting system called WT-Bird.

2. Applied Method of the detection system

The applied detection method is based on noise monitoring. Continuously monitoring of the wind turbine noise offers immediate information about events occurring in or around a wind turbine. Collision of a bird with the wind turbine is audible and detectable with microphones that are attached on carefully chosen places. When the noise monitoring is combined with image monitoring (i.e. video camera), it is also possible to identify the species of the birds.
This way of monitoring can be carried out with a relative inexpensive system that enlarges its implementation. It can be attached to the turbine quiet easily, without special accommodations to the wind turbine itself.

3. Description of the system

The system can be divided into the following parts, each with their own functionality:

1. Sound measurement and noise analysis
2. Video registration
3. Overall system.

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

3.1 Sound measurement and noise analysis

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

- Noise registration.
- Distinguishes between abnormal noise (potential bird collision) and normal characteristic wind turbine sounds.

Continuously the sound of the turbine will be measured. In real time, or at least with a very short time delay, this sound measurement will be 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 will be stored.
The sound recordings are taken inside the turbine tower, eventually in the nacelle, but not on the rotor. It should be clear that each type of wind turbine and even each wind turbine itself has a different sound characteristic. Therefore the system should be adjusted (learned) for each specific turbine.

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. The system could be expanded in the future with a third microphone, mic 3 to register the sound outside the turbine.

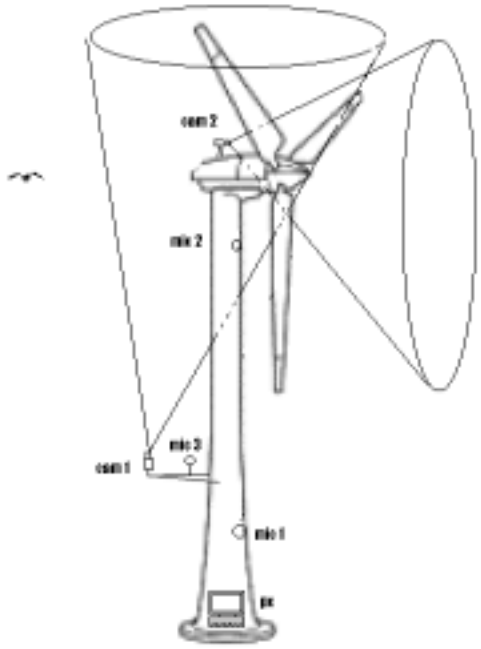

Fig. 1: Schematic overview of the system's sensors

3.2 Video registration

As mentioned earlier the detection system has two goals: one to register abnormal sounds and second to detect the species of a bird after the detection of a collision. The second goal can be achieved using video registration.

Video registration in this application is quite difficult due to the following reasons:

- Where do the birds collide: rotor, nacelle or tower? And at which height?
- Birds can collide during the day or at night.
- Sometimes birds fly through the wake behind the rotor. It is known they can be killed because of the heavy turbulence in the wakes.
- 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 foreseen with two cameras', which can be seen in figure 1. Camera 1 and 2 are used to register the birds, which collide with the turbine mast, nacelle or rotor. In the future a third camera could be used to register the birds that fly through the wakes.

The video registrations are only stored when the sound registration detects an abnormality, like a bird collision. So the video 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 see the flying bird, before collision. From these images bird recognition can be made.

3.3 Overall system

The sound registration, sound analysis and video registration, will be done by using a PC-based system. This PC can be everywhere in the turbine, in figure 1; you can see the PC installed at the bottom of the tower.

The advantages of the WT-Bird system:

- Using these sound and video 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 sounds will be stored when an abnormality, relative to the wind turbine noise appeared.
- 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 will be glued against the mast. See figure 2.

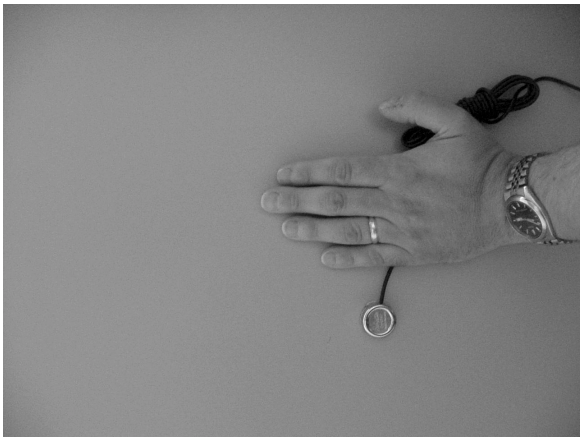

Fig. 2: Microphone at the inside of the turbine tower

4. Field experiments and results

The first experiments were executed to retrieve information about the possibilities to detect bird collisions. Concerning the small weight of birds with respect to the mass of wind turbines, one makes very often the mistake that the collision couldn't be heard.

So 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.

4.1 Simulated bird collisions against the tower of a 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 were used with different weights, to simulate different species of birds. These bags of sand were just thrown against the tower of a wind turbine. Figure 3 shows some examples that were used.

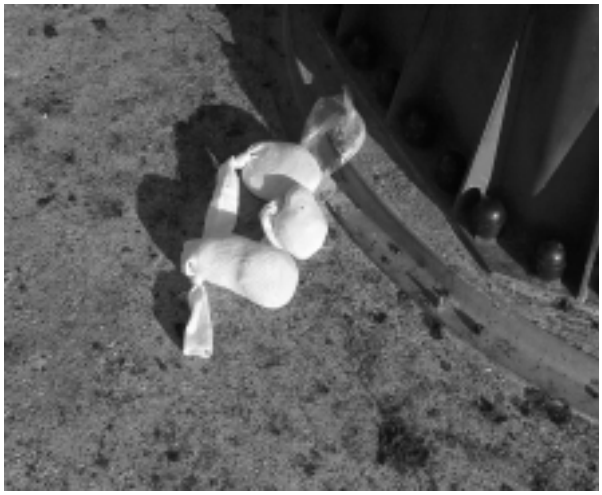

Fig. 3: Sand bags used to simulate birds

An example of the sound measured inside the turbine tower at the moment of simulation of a bird collision is shown in figure 4. This sound registration shows clearly that a "bird" collisions can be detected.

4.2 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.

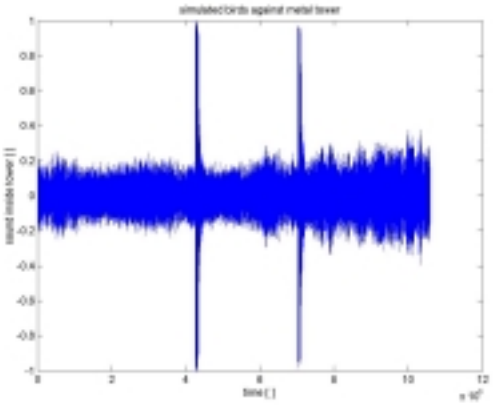

Fig. 4: Sound registration during simulated bird collision against a wind turbine mast.

In figure 5 the tennis ball shooting machine and the turbine are shown. After some practice, hitting the blades was not a problem anymore.

Fig. 5: Tennis ball machine used to simulate bird collisions against the blades

A hit against the rotor blade is shown in figure 6.

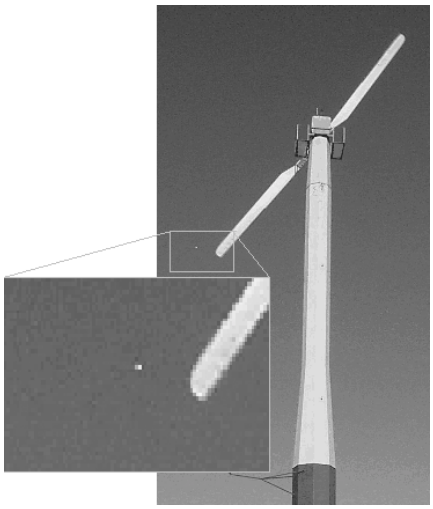

Fig. 6: Tennis ball flies against the rotor blade; the tennis ball is enlarged.

Figure 7 shows the sound registration of a tennis balls hitting the blades of another wind turbine. Although the impacts are less clear as in figure 4 still we can register and determine the impacts. The basic noise (normal noise during operation) of the turbine shown in figure 7 has a high level, much higher then seen at other turbines. Despite of that registration appeared to be possible.

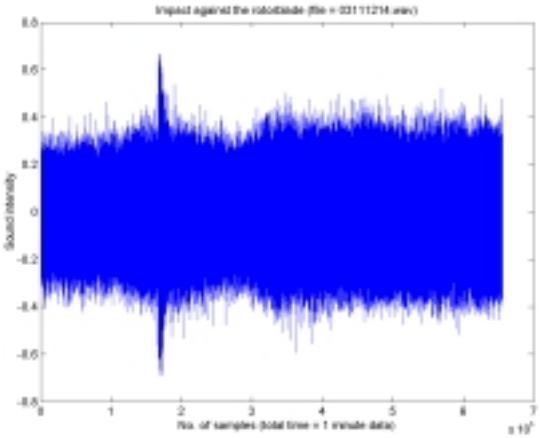

Fig. 7: Sound registration of two tennis balls against the rotor.

Looking at the spectrum of the data (see figure 8) with and without an impact, we can see clearly that FFT and especially the RMS (Root-Mean-Square) value of the determined region can be used to identify if an impact occurred. We see the FFT results of three time fragments. The fragment (031111214.wav) with the thick line is where we have an impact on the blades.

4. Conclusions and discussion

We have developed and built a prototype of a bird impact detection system. The first results of the systems clearly shows that birds flying against the wind turbine mast or rotor can be detected using sound recording and on-line data analysis. From a technical point of view the basic bird impact detection system has to be improved and tested on real offshore locations were, as you can imagine, the environmental conditions are more harsh.
Furthermore extra offshore sounds like breaking waves are to be incorporated in the learning proces. The program has to be adapted to several weather conditions like hard rain etc.

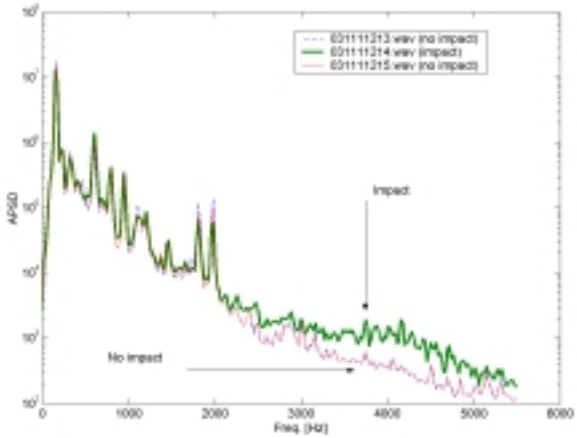

Fig. 8: FFT results of three sound recordings

It can be concluded that the system seems to be very promising and that it may be possible to forego applying system barriers in implementing offshore wind turbines.

References

[1] Monitoring van vogels op het NSW, N. Jeurink & E. Dönszelmann (Tauw), 2002

[2] WT-Bird. Results of tests with the WT-Bird system at the location Maasvlakte. (in Dutch)

[3] Application of Acoustic Bird Monitoring for the Wind Power Industry, William R. Evans, National Avian Wind Power Planning Meeting III.