Measure of Visibility as Collision Risk Factor between Birds and Wind Turbines

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Objectives

Collisions between birds and wind turbines is a limiting factor to wind power development in Switzerland. Determining poor flight conditions, associated with bad visibility, is key to reduce these accidents, by adopting an adequate response in the wind farm.
The objective of this project is to develop a system able to measure visibility conditions with pictures taken by RGB cameras. The system must work during night and day, in real time and be able to forecast upcoming conditions.

Methodology

Images to analyse

Image Processing

Day time vs Night time Classification

Picture separation based on the mean value of pixels

Night Time : Light Source Quantification

Gaussian Noise Removal

Spot Light Detection and Cropping around it

Thresholding to keep bright pixels, computation of the score as the mean value of the image

Neural Network Training

Image Labelling

Daytime image segmentation and choice of relevant areas; around the wind turbine

Sobel Filtering (high pass) to detect edges

Categorize visibility according to the amount of edges in the interest zone

Training

Day time : Convolutional Neural Network

Robust prediction tool that computes visibility score and determines a category

Assigned visibility score and category to each image

Visibility Forecast

Appropriate response to the visibility conditions

Results

Day time ☼

During the training phase, 5500 images were labelled with three categories, High, Medium and Low visibility. Once labelled, the images are used to train the newly developed Neural Network.
After full training, the Neural Network reaches 87% of validation accuracy and is able to analyse new images from any place. The confusion matrix below shows the accuracy of the Network. Two sample pictures with their respective predictions are also shown.

High:0.0 Medium:0.19 Low:0.81

High:1.0 Medium:0.0 Low:0.0

Night time ☽

The histograms on the right represent the distribution of night visibility scores for three different sets of images. Each set was taken from a different point of view and distance from the turbine.
The categorization is straightforward, left bars represent low visibility conditions and right bars represent high visibility conditions.
The variation between histograms is due to different placement of the camera and changing weather between the time when the pictures were taken.
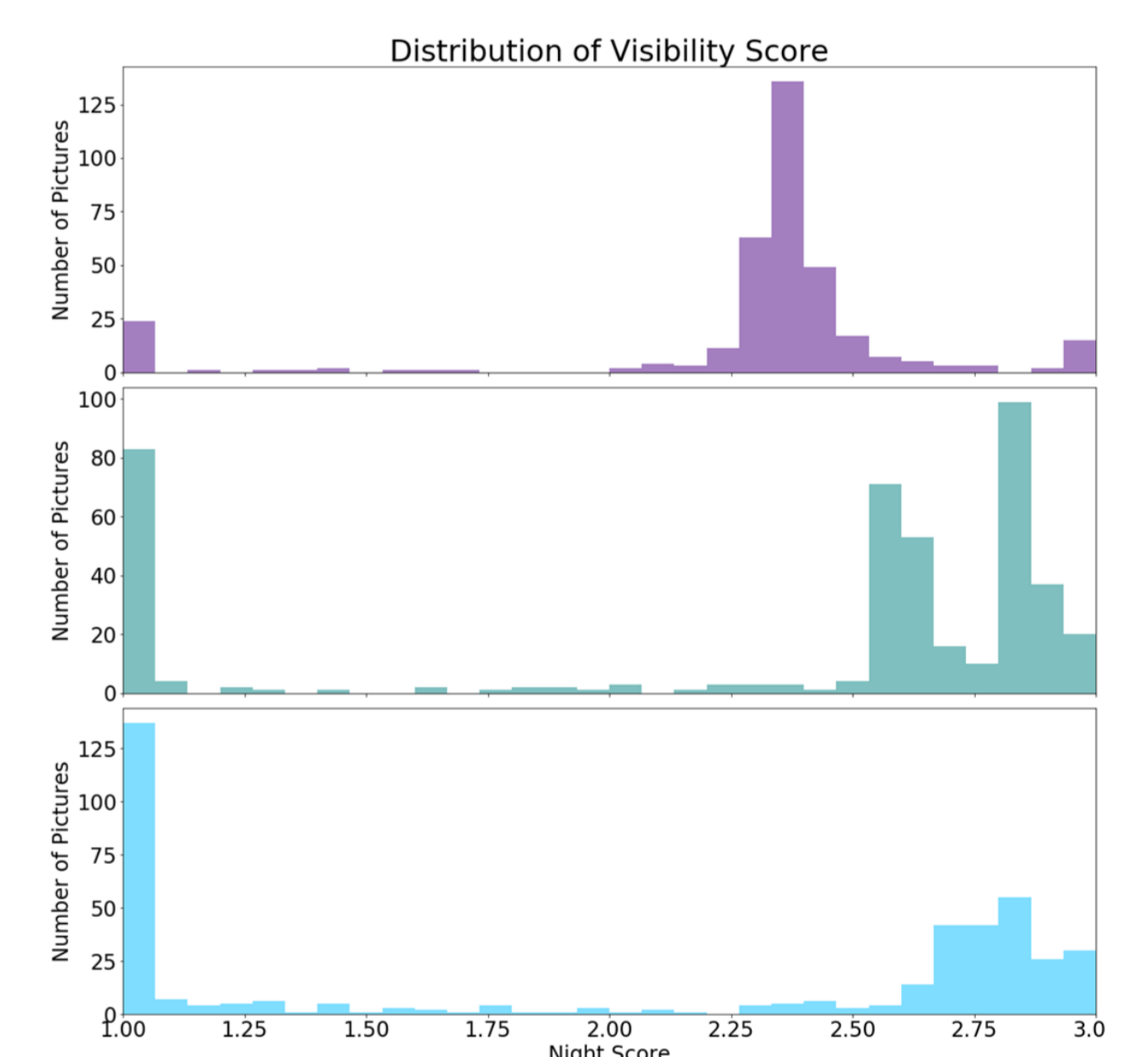
Forecasting →

The ability to forecast the visibility score is essential to analyse the persistence of the conditions and to decide which response should be adopted in the wind farm.
A Simple Exponential Smoothing forecast was selected for its simplicity, easy implementation and performance. Meteorological data is used to help the model achieve a more accurate forecast.
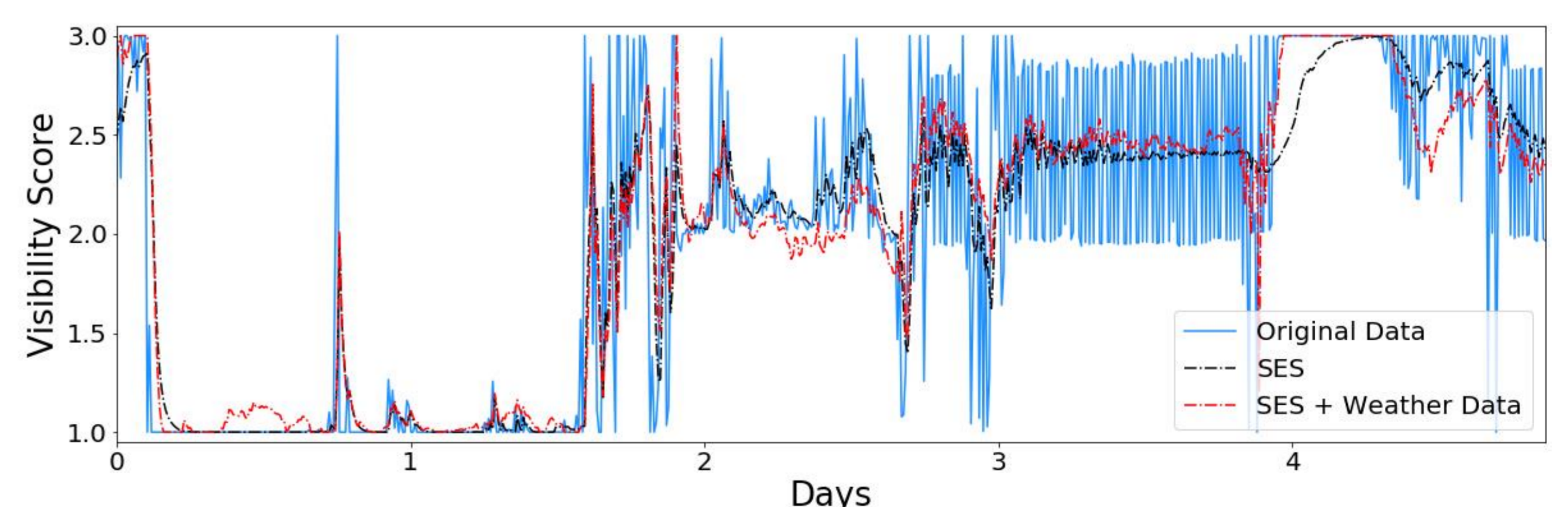
Conclusion

We created a reliable measurement system that can be implemented in any wind farm. For our case study, implementing the system on several autonomous microcontrollers around the wind farm is under consideration. If the combination of migration and poor visibility conditions pose a risk for birds one can imagine to shutdown the wind turbines. We propose another viable alternative: **make the turbines more visible to birds.** Illuminating them with **flashing UV light**. Since birds have a photoreceptor cell type **sensitive to UV** wavelength. This alternative is **affordable** and does not interrupt the energy production. The lights can be switched on and off **instantaneously,** providing a rapid response **unlike the shutdown of a turbine.**