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# Intelligent audio bird repeller for transmission line tower based on bird species variation

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**Abstract.** Bird-caused damages for overhead transmission lines become one of the main fault types of the power grid, which will affect the safety and reliability of power grid operation and usually bring huge economic losses. The effectiveness of existing bird repeller would deteriorate obviously due to the habituation of birds. Bird bioacoustic vocalization can elicit the avoidance behaviour of conspecific, which can delay the habituation process of birds to bird repeller. An intelligent bird repeller based on bird species variations was proposed. Based on birds' appearance and vocalization respectively, two light weight networks were designed to identify the approaching bird species; according to the approaching bird species, the corresponding repellent modes were selected; the target was to improve the long-term effectiveness of the bird repeller, which is helpful to reduce the occurrence probability of bird-caused damages.

## 1. Introduction

The bird movement on the cross arm of transmission tower may cause the short circuit, which is known as bird-caused damage. Bird-caused damage has become one of the main fault forms, which seriously affect the safety and reliability of the power grid and cause the economic loss of the electric power enterprise. Currently, there are mainly four bird repellent methods in transmission towers: 1. Visual bird repeller. Such as wind-reflective bird repeller, expelling birds by reflecting sunlight when there is wind [1]; Laser bird repeller similarly repels the birds by launching a bird-sensitive green laser with a wavelength of 532 nm [2]; 2. Physical bird repeller. Anti-bird thorns use their spikes to prevent birds from moving above the insulator string or building their nest on the cross arm; Bird repelling board can be installed above the insulator string to prevent guano or falling objects from falling onto the insulator string, but it is too complicated to be installed [3]; 3. Ultrasonic bird repeller. When birds are exposed to large decibel ultrasound environment for a long time, their nervous system will suffer serious physical damage, even leads to anorexia, convulsions, hearing loss and other complications, eventually birds will die in pain. The device uses above mentioned principles forcing birds to fly away from the protected region [4]; 4. Auditory bird repeller. Most audio bird repellents force birds to fly away from the target area by playing gunshots or raptor sounds [5]. For special birds, the sound of bird being arrested, injured, and escaping can be used to achieve the purpose of driving away the conspecific birds. However, this kind of sound also may attract other bird species which is not conspecific [6].



The existing bird repelling devices are lack of species pertinence, although most of them can effectively repel birds in the early stage, birds will gradually adapt to the bird repeller after long-term operation, reducing the effectiveness of this device. The use of specific biological vocalization can delay the adaptability of birds for the bird repeller, but first we need to identify the bird species when they approach to the device [7]. This paper proposed an intelligent audio bird repeller for transmission tower, which based on the bird species difference. It can identify the bird species using the deep convolutional neural network, then the corresponding bird repellent sound is played to achieve the purpose of driving away the bird. The second chapter describes the structure of the new bird repellent equipment; The third chapter introduces the bird appearance and vocalization recognition methods based on two different deep convolutional neural network; The fourth chapter introduces the construction of bird repelling mode based on avoidance behavior; The fifth chapter is the conclusion.

## 2. The Structure of bird repellent equipment

The structure of proposed bird repeller is shown in Figure 1. The repeller contains six modules: the infrared detection module, the audio acquisition module, the image acquisition module, the embedded system, the audio player module and power supply module. The repellent sound will be played only when the birds are approaching, which brings the advantage of low energy consumption. Through the comprehensive evaluation of the infrared detection module and the audio collection module to determine whether the birds are close to, as long as one module detects birds, it is confirmed that there are birds nearby, then the image acquisition module will start to collect images, and the embedded system will detect the image and audio for verifying the bird species which close to the device. After all of this, the system will automatically select the corresponding bird repellent sound and plays it to specifically expel the birds. The equipment is powered by solar panels and batteries to ensure long-term operation of the equipment.

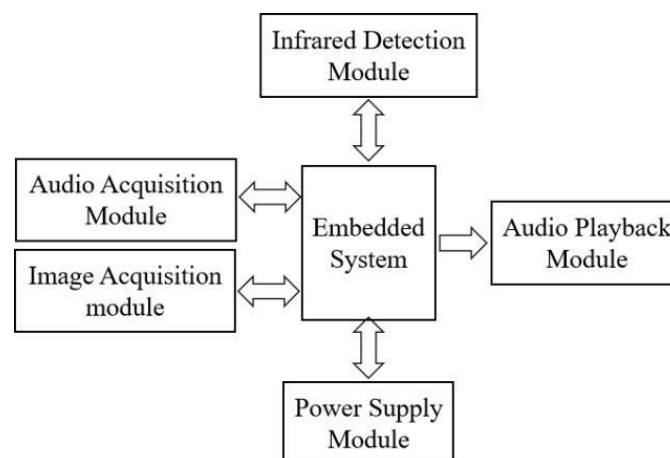


Figure 1 The structure of bird repeller

## 3. Bird species identification based on appearance and vocalization

Bird's bioacoustic vocalization, such as alarm and distress call, can elicit the avoidance behaviour of conspecific, but also can attract birds from other species [8]. So it is necessary to identify the bird species to realize effective bird repelling with bioacoustic vocalization. At the species level, the appearance and vocalization of bird are relatively stable, between different species existing distinct characteristics, so the species identification can be realized through classifying the bird vocalization and appearance [9].

The spectrogram was commonly used to show the time-frequency characteristics of bird vocalization, in which bird vocalization zooms can be treated as a special object, so we can identify the bird species by training the spectrogram of the bird's vocal. Deep convolutional neural network (DCNN) performs excellently in image recognition, which learns the image features automatically via convolutional and pooling layers, then classify the features by fully-connected layers to realize the recognition of images. Local connections, the weight sharing operation and the pooling operation can effectively reduce the

complexity of the network and reduce the number of trained parameters [10]. Two different DCNNs were designed to identify the bird species by image and vocalization respectively.

The architecture of the bird species identification model based on vocalization is shown in figure 2, the raw audio of bird vocalization is cut into some segments with length of 50ms, then each segment is fed into the model sequentially. The first two layers are temporary convolution layer and frequency convolution layer respectively, which can be considered as filter banks, then a “time-frequency” representation would be outputted from these two layers. Maximum pooling is performed to decrease the dimension of the “time-frequency” representation. To extract the sequential feature of the adjacent segments, three Long Short-Term Memory (LSTM) [11] layers are utilized. At last, full connect layer and softmax layer are set to identify the bird species.

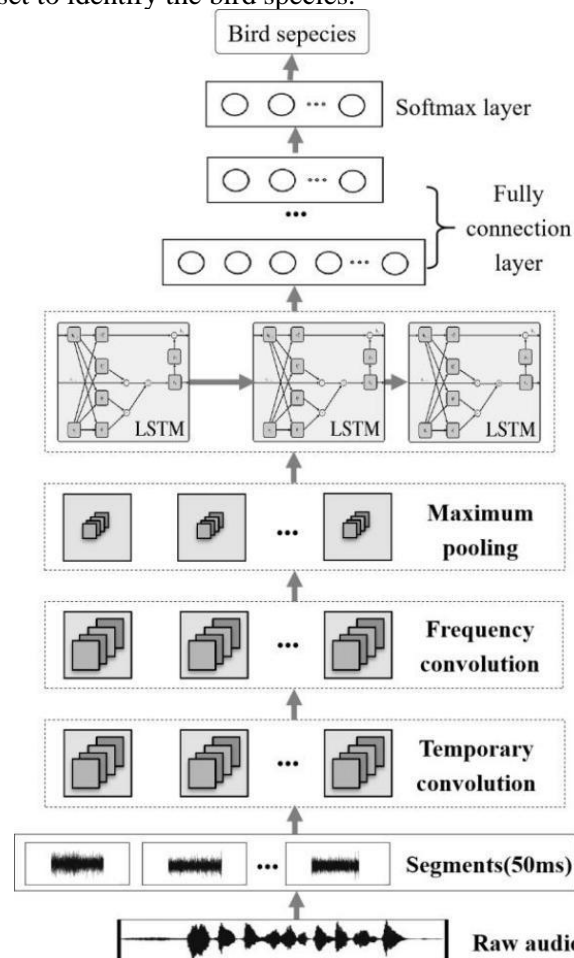


Figure 2 Model architecture of bird species identification based on vocalization

The above model is computationally expensive and memory intensive, which can't be deployed in embedded device with low memory resource. Therefore, the model compression should be performed on this model. Because there are always redundant parameters in neural network model, so model truncation becomes a kind of effective model compression method. The flow chart of designed model truncation method is shown in figure 3. With the aim of low energy cost and relative high accuracy, the energy cost of each layer is evaluated, then the truncation order is determined from high to low. In each layer, redundant parameter truncation is tried and the parameters are local fine tuning until reaching the highest accuracy. Then global fine tuning is carried out to form the compressed model.

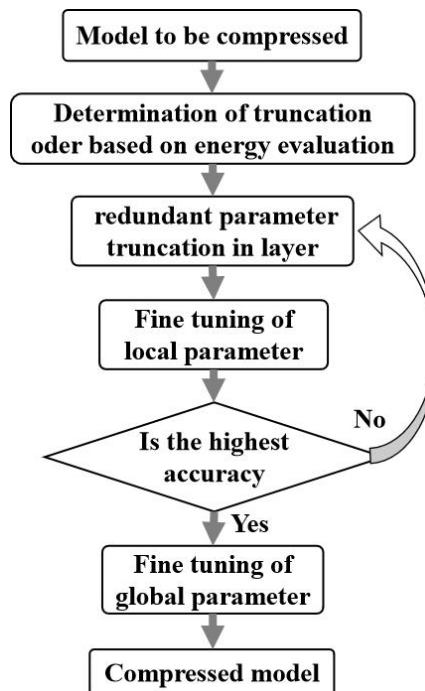


Figure 3 Flow chart of model compression method

YOLO-LITE is a real-time object detection model developed to run on portable devices while lacking a Graphics Processing Unit. Although the MAP is not the best, the detection speed is the fastest so far [12]. Considering the limited calculation ability of embedded system, the YOLO-LITE model is used to identify the bird species based on images. The ideal results of two identification model are the same, otherwise, two kinds of corresponding bird repellent audio will be played one after another.

The itop4412 development board is chosen as the core board of embedded system, in which the identification models are operated automatically. And the PlayStation 3 Eye is introduced to realize audio and image detection. It is capable of capturing standard video with frame rates of 60 hertz at a 640×480-pixel resolution, and 120 hertz at 320×240 pixels. There has a four-capsule microphone array, with which the PlayStation 3 can employ technology for background noise suppression. The microphone array operates with each channel processing 16-bit samples at a sampling rate of 48 kilohertz, and a signal-to-noise ratio of 90 decibels [13]. It's very suitable for the recognition under wild environment.

#### 4. Bird repellent mode construction

The construction of bird repellent mode is also important for the bird repeller. To a large extent the effectiveness of the bird repeller depends on choosing a suitable bird repellent mode. Field test should be performed to set up the bird repellent mode collection through analyzing the avoidance behaviour of bird. First, the repellent vocalizations are gathered by recording or downloading from website. Then, the parameters, such as the duration, period and intensity of vocalization, are altered to implement different tests, and the avoidance behaviors are observed. During the tests, the below patterns are considered:

- (1) Initial number of birds: the total number of birds counted prior to the test.
- (2) First departure: the time from the test begin to the moment when the first individuals left (in seconds).
- (3) Number of departures: total number of birds that fly off in response to the vocalization.

For one specialized bird species, at least one test should be performed to decide the vocalization and its playing parameters, different combinations which form the bird's repellent mode collection. When repelling is needed, the repellent mode would be determined by the bird species, also, the playing parameters are time-varying within the allowable range of the specific repellent mode to defer the habituation process of birds.

## 5. Conclusion

An intelligent bird repeller is proposed in this paper, first, the approaching bird species is identified by its appearance and vocalization using two powerful deep learning network. Then the bird repellent mode is selected according to the bird species. At last, the specific audio will be played to repel the bird. Here, the bird repellent modes are constructed through the analysis of avoidance behaviour, and the audios are bioacoustic, which can procrastinate the adaptability of birds for the bird repeller.

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