Real Time Bird Call Classifier

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Introduction

- Project aims to develop a classifier to identify bird species through their calls
- The classifier must have accuracy of 80% or higher
- Needs to deliver classification results in real time
- Classification results, audio recordings and geographical data must be saved to a database

System Components

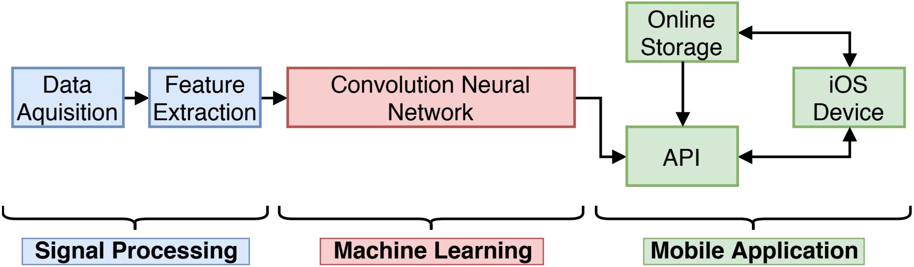


Figure: System components of the real time bird call classifier

Data Acquisition

- Data is needed to train any Artificial Neural Network (ANN)
- Xeno-Canto is an open platform database containing bird calls from around the world
- A total of 590 South African bird species recordings were obtained
- Due to processing power limitations, 10 bird species are used
- Recordings were cut and processed through mean analysis
- Resulted in a total of 3560 sound files to be used to train an ANN

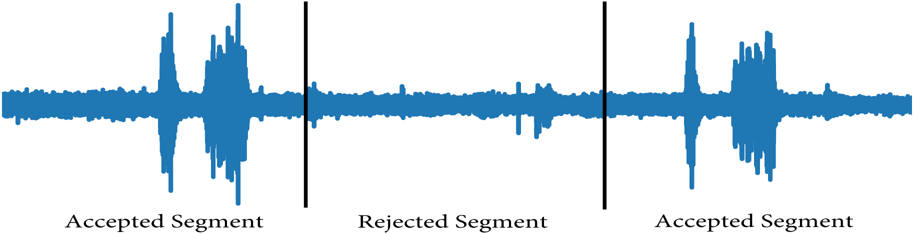


Figure: Mean analysis of an audio recording

Feature Extraction

- The bird call recordings were filtered from 20 Hz to 12 000 Hz to eliminate noise
- Mel-Frequency Cepstral Coefficients (MFCCs) were used as the features that the Neural Network must learn
- Only the first 13 MFC coefficients are computed and used
- Images of the MFCC plots were generated and saved
- The MFCC extraction is handled through the use of the Python library, Librosa

MFCC Key Equations

Discrete Fourier Transform

$$X[k] = \sum_{n=0}^{N-1} x[n] \cdot e^{\frac{-j2\pi kn}{N}} \tag{1}$$

Mel-Scale Transformation

$$M(f) = 1127 \cdot ln(1 + \frac{f}{700}) \tag{2}$$

Discrete Cosine Transform with logarithm

$$MFCC = \sum_{n=0}^{N-1} log(X[k]) \cdot cos\left[\frac{\pi}{N}(n + \frac{1}{2})k\right] \tag{3}$$

CNN Architecture - Layers

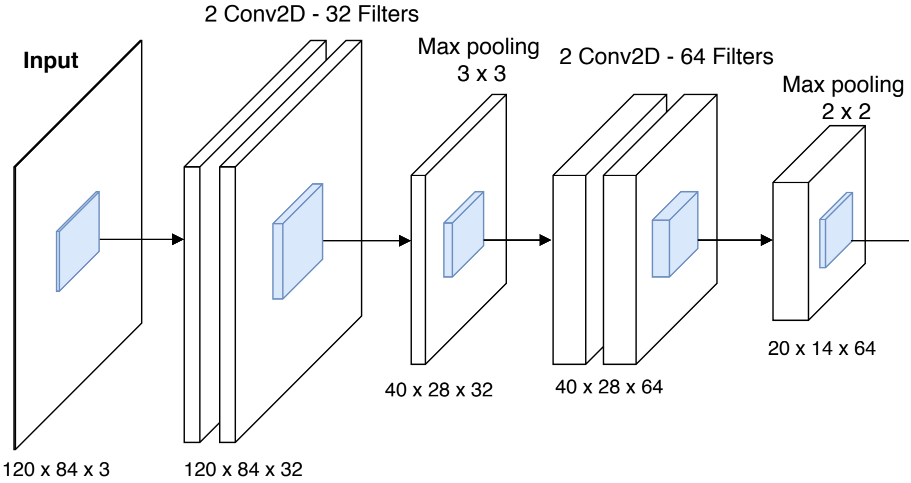


Figure: Layers 1 to 7 of the CNN

CNN Architecture - Layers

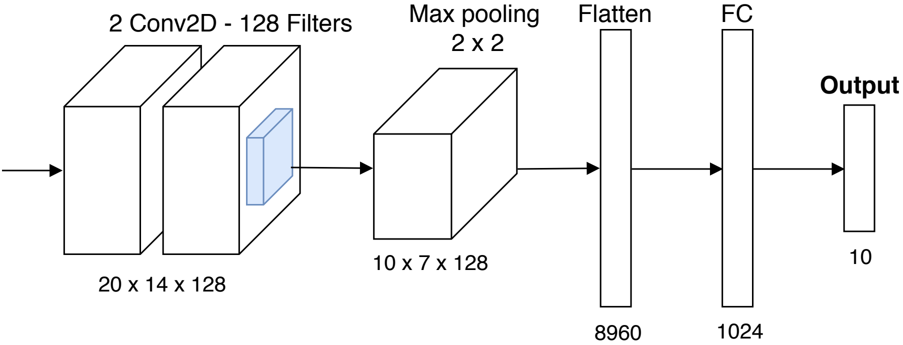


Figure: Layers 8 to 13 of the CNN

CNN Architecture - Hyperparameters

- Filters had size of 3 x 3
- Dropout of 50% utilized at each layer except for Dense 1024 layer, which uses 80%
- Rectified Linear Unit function (Relu) is used as the activation functions of each layer
- Adam Optimizer chosen as the optimizer
- Categorical Cross Entropy chosen as the loss function
- Softmax Activation function used for output layer
- Batch size of 5
- Learning Rate of 0.00001
- Trained over 3000 epochs

Results - Accuracy

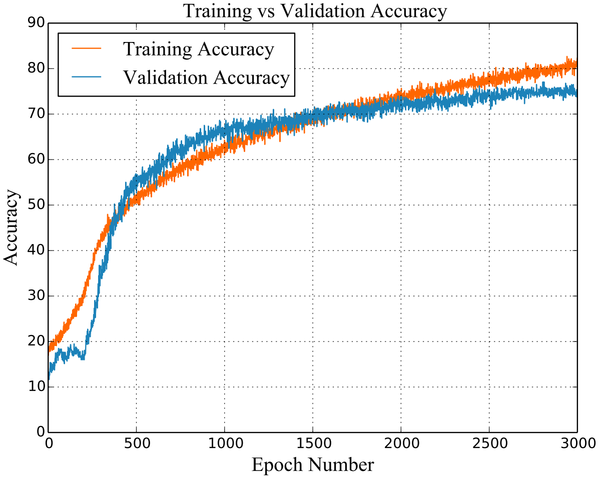


Figure: Training and validation accuracy over 3000 epochs

Results - Loss

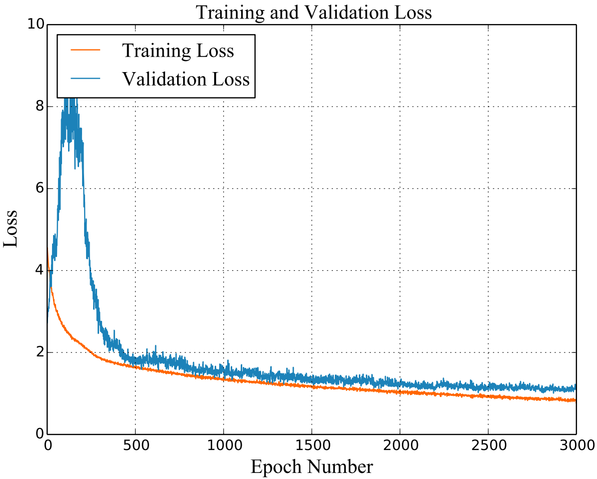
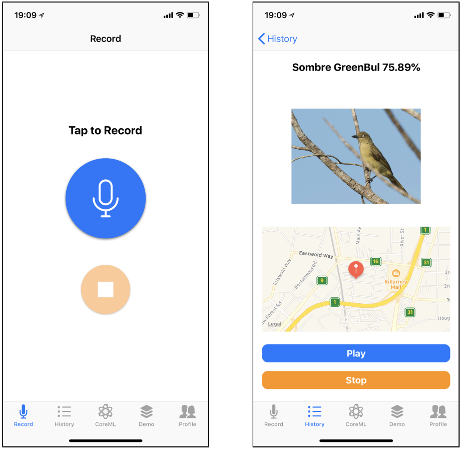


Figure: Training and validation loss over 3000 epochs

iOS Application

Functionality

- Utilizes devices built in microphone
- GPS for location data
- Firebase Realtime Database
- Firebase Storage Bucket



Sombre GreenBul 75.89%

(a) Record

(b) Classification

Figure: iOS application screenshots

API Server

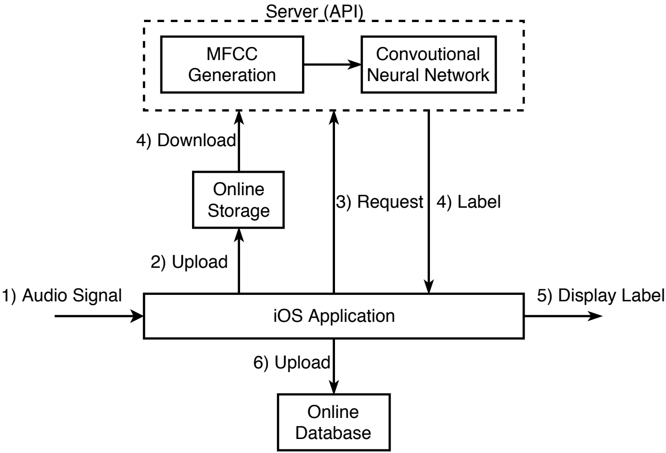


Figure: Mobile application data flow

Future Recommendations

- Increase the number of bird species to classify
- Perform data processing on the mobile device
- Ability to identify if a bird call is present
- Classify multiple birds in the same audio clip
- Validate and verify the quality of the data
- Develop a training pipeline that make use of user classified sounds to train and enhance the model

Conclusion

- CNN classified 10 South African birds with an accuracy of 77%
- Mobile application successfully communicated with classifier on a server and performs classification in real time
- Classification and location information is saved to database

The End

Questions?