



Artificial Intelligence-Based Harmful Bird Deterrent System in Smart Agriculture

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Abstract

This research was primarily carried out to ensure effective application of artificial intelligence in the form of Convolutional Neural Network as bird deterrent solution in a rice farm in smart agriculture on real time. Here, the most specialized rice eater of all granivorous birds was identified as Java sparrow or Java rice bird known scientifically as *Padda Oryzivora*. In this research work, an enhanced Convolutional Neural Network (CNN) model was developed and applied in identifying the *Padda Oryzivora* with the training data sets as the different pictures of the birds. The different data collected as the different pictures of the bird as captured by the cameras were pre-processed by Raspberry pi 2 and used as the training data sets for this research in Google colab platform using python language. Then, an algorithm was developed to monitor bird classification by the developed enhanced convolutional neural network (CNN) and use such classification to either activate the speakers using the predator sound when harmful sparrow birds were classified by the model. Subsequently, the developed algorithm remained inactive when a beneficial bird was classified by the model. Once, the harmful sparrow birds (*Padda Oryzivora*) heard the sound of the predator (squirrel), it assumed that the squirrel was around and flew away. This work was simulated in google colab platform using 700 images of both harmful sparrow and beneficial birds. The developed model was able to show accuracy of 97%, precision of 96.5%, recall of 0.965 and f1 score of 0.965. The essence of this research work was to allow other beneficial birds like insectivorous ones which feed on insects and other plant pests to stay and feed on those pests for biological pest control which would increase the rice yield in the long run. It only activated the scaring sound of the predator (squirrel) when a sparrow bird was sighted by the cameras within the rice farm.

Keywords: Artificial Intelligence, Smart Farming, Rice Sparrow Bird, Predator Sound and Machine Learning.

1. Introduction

Agriculture is a major source of income and feeding for most developing nations. Presently, it contributes well over a quarter of the gross domestic product (GDP) in Nigeria and two-thirds of the populace depends on it for their source of livelihood. Of the numerous problems faced by the sector, the major seems to be of pest infestations in farms (Montras et al., 2019). Pests are broadly classified as harmful organisms (Plants and Animals) that cause harm to people, their food or environment. Birds are the most destructive to farm crops according to Pinowski and Zaj (2019), and they cause total loss of farm produce if no control systems are available. Birds are the most destructive to farm crops and birds like Java Sparrows are the most

destructive bird pests for rice. This research work was carried out to ensure the use of artificial intelligence in the form of Convolutional neural network to model a bird deterrent in a rice farm. After careful observation of the different bird deterrent solutions in a rice farm, it was discovered that most of them were not specific in the type of birds to be scared away and the right predator sound for such birds. Going by this research, it was discovered that in the process of scaring away the birds, some vital insectivorous birds were also scared away. These insectivorous birds are supposed to feed on insects and other rice pests as a biological means of controlling the pest population, thereby increasing the productivity of rice. Hence, this research work ensured that only the Paddy Oryzivora (Rice eating Birds) were scared by the simulated sound of the potential predator which was squirrel whenever their presence was indicated in the farm by the cameras which captured their images.

2. Literature Review

2.1 Smart Agriculture

Smart Agriculture is an aspect of agriculture that employs technology in the farm to achieve increased productivity. It is also called Satellite agriculture or precision farming. Precision agriculture is about doing the right thing, in the right place, in the right way, at the right time, through the right procedures. Managing crop production inputs such as water, seed, fertilizer etc to increase yield, quality, profit, reduce waste and become eco-friendly. Smart farming intends to match agricultural inputs and practices as per crop and agro-climatic conditions to improve the accuracy of their applications. (Ankush et al 2018 ; Ramesh, Srikanth, and Srinath, 2020).

2.2 Artificial Intelligent System

Artificial intelligence system is a system whose developed intelligence is equal or greater than the human intelligence. It ranges from genetic algorithm, expert system, fuzzy logic and artificial neural network. Artificial neural network is divided into single perception, Multi perception, Feed forward, recurrent and Convolutional neural network. In the course of this study, a convolutional neural network model was developed and used. The artificial neural network (ANN) was pioneered more than 40 years ago and nowadays, there has been a great interest in neural network since an artificial network shares some of the physical and behavioural aspects of a biological one. The artificial neural network (ANN) structure is a parallel system that is based on human brain's biological neural process used to solve complex problems where it tries to imitate into mathematical models. A few authors Deepak et al (2017) had briefly discussed the architecture of artificial neural network (ANN). (O'Neal, Engel and Frankenberger, 2020).

Machine learning has also applied image recognition to vineyard and agricultural objects with 69% accuracy (Paolo 2019). Oluwole, Adefemi and Ade-Omoway (2020), presented a bird identification system based on bird features identification-image processing and has been deployed with Raspberry pi. The device utilized a model trained separately using Haar features, Histogram of Oriented Gradients (HOG) and Local Binary Patterns (LBP), Python and Open CV library software. The system achieved 76% highest accuracy from Harr, 72% from LBP and 27% from HOG, but did not specify in the particular bird to identify. Ismael, Mouhamadu and Amadou (2023) presented a conference paper on pest bird detection approach in rice crops using pre-trained you only look once version 4 (YOLOv4) detector and transfer learning. Divyansh and Patro (2023) presented a research work on real-time detection of birds for farm surveillance using you only look once version 7 (YOLOv7) model. Marcon et al (2023) presented a research work on a system using artificial intelligence to detect and scare bird flocks in the protection of ripening fruit. Though these research works on YOLO model can work optimally in environments where birds are completely regarded as either pests or nuisance like in the protection of ripe fruits and airports. However, to apply it in other areas like rice production, the limitations will be as follows:

- It has reduced accuracy and recall with high localized error when compared to a CNN model.

- You only look once (YOLO) model is a real time object detection using CNN architecture to detect flock of birds based on the number of frame boxes with bird images set at a particular threshold. Once the threshold is surpassed, an actuator is triggered. Hence, it cannot detect small or few birds.
- It finds it extremely difficult to detect close objects.
- It was not specific in the type of birds to scare away
- It scared away both beneficial and harmful birds

2.3 Research Gaps

The research gaps from the review of related works done in smart agriculture are as follows:

- A bird deterrent system that recognises specific specie of harmful bird in a rice farm and produces the sound of the predator to scare away the bird has not been developed in precision agriculture.
- A bird deterrent system that classifies rice birds into harmful and beneficial birds and uses such intelligence in deterrence has not been developed in precision agriculture.
- A bird deterrent system that allows beneficial insectivorous birds to do biological pest control in the rice farm in order to increase productivity without scaring away the birds has not been added to precision agriculture.
- Precision agriculture is yet to classify the rice farm as a dynamic entity considering dynamics such as bird migration and climate change and incorporate this intelligence in the bird deterrent system.

3. Materials

3.1 Hardware Materials

These are those physical tools that can be touched, which were deployed in the course of this research work. Some basic ones include:

(a) Cameras

These are the devices strategically positioned in the farm to capture the different images of the sparrow birds. They provided the much needed image data sets for the training of the enhanced convolutional neural network(CNN) model as shown in plate 1.



Plate 1: A Digital 4K Camera Deployed to Capture Images of the Sparrow birds

(b) Speakers

The sounds of the squirrels (predator) were recorded in the rice farm using a sound recorder and were simulated by the model using well positioned digital speakers in the rice farm so as to scare away the sparrow birds whenever they are sighted by the cameras in the rice farm.

(c) Raspberry Pi 2

The Raspberry Pi 2 is a device (Small Computer) that was used for the Sparrow bird image processing and video streaming. It operated on Raspbian operating system, a version of Linux and a modified version of Debian. The preferred language used was Python which was used to develop the control programme.

3.2 Software Materials

These are programmes and software deployed in the realization of the objectives of this research work. Some of the software materials are discussed below.

(a) Training Method

Here, the training method for this research was back-propagation (BP) training method. This method used the data sets to train the convolutional neural network (CNN) model. The learning process in an Artificial Neural Network (ANN) entail adjusting the weights associated with the transfer functions between neurons comparing artificial neural network (ANN) output with observed data. The back-propagation (BP) was used to train the feed-forward neural network to minimize error (which is the difference between the desired output and the calculated output). (Deepak et al 2017).

(b) Python Language

It is a widely used programming language because of its readability and dense syntax. It was used to train the model in the Google Colab platform for rice bird recognition and classifications (Nwonye et al 2024). It covered all the processes and procedures followed in the course of carrying out this research work as detailed in section 4.

3.3 Data Collection

Here, data collection was divided into three stages:

- (a) The use of questionnaires to identify the most dangerous rice bird in the selected rice farms.
- (b) The capturing of the different images of the selected rice-harmful bird (Sparrow birds) with Camera.
- (c) The capturing of the Sound of the potential predator (Squirrel) with a sound recorder.

(a) Data Collection using Questionnaires

In the course of this research, fifty rice farmers were interviewed and five rice farms were selected in Nenwe community of Aninri local government area in Enugu state, Nigeria, so as to identify the prevalent harmful rice- birds in Nenwe. Nenwe was chosen for this research work because it is one of the major rice growing communities in Enugu state and the south eastern Nigeria at large. Questionnaires were distributed to the selected fifty rice farmers in Nenwe so as to extract vital information from them as shown in appendix I. Benefits of the questionnaires in this research study are as follows:

- It provided the information that sparrow birds are the most dangerous birds affecting rice production negatively in Nenwe community.
- It provided information that all the birds in the rice are not harmful.
- It provided the information that some birds in the farm feed on insect pests that attack the rice plant there by performing biological pest control in the farm.
- It provided the information that squirrel is the predator for the harmful sparrow birds.
- It also provided an avenue that helped in obtaining information from different rice farmers during the course of this research.
- It was with this questionnaire that permission was granted to use the selected rice farms in plates 2.4 and 2.5 for this research study.

(b) Image Capturing of the Sparrow Birds

One hundred different images of the harmful sparrow birds were captured using a high- resolution 4k digital camera as shown in plate 3.1. The camera has 1 giga byte internal memory with 1 terra byte external SD memory card. One of the captured images of sparrow bird was shown in plate 2.

(c) Predator (squirrel) Sound Capturing

The sounds of the squirrels (predator) were recorded in the rice farm using sound recorder and were simulated by the model using well positioned digital speakers in the rice farm so as to scare away the sparrow birds whenever they are sighted by the cameras in the rice farm.



Plate 2: Sample Image of Sparrow bird captured in a Rice Farm

4.0 Methodology

4.1 Image Pre-processing for Development of Dataset for Model Training

Here, the dataset for model training was generated from the flow chart in Figure 1

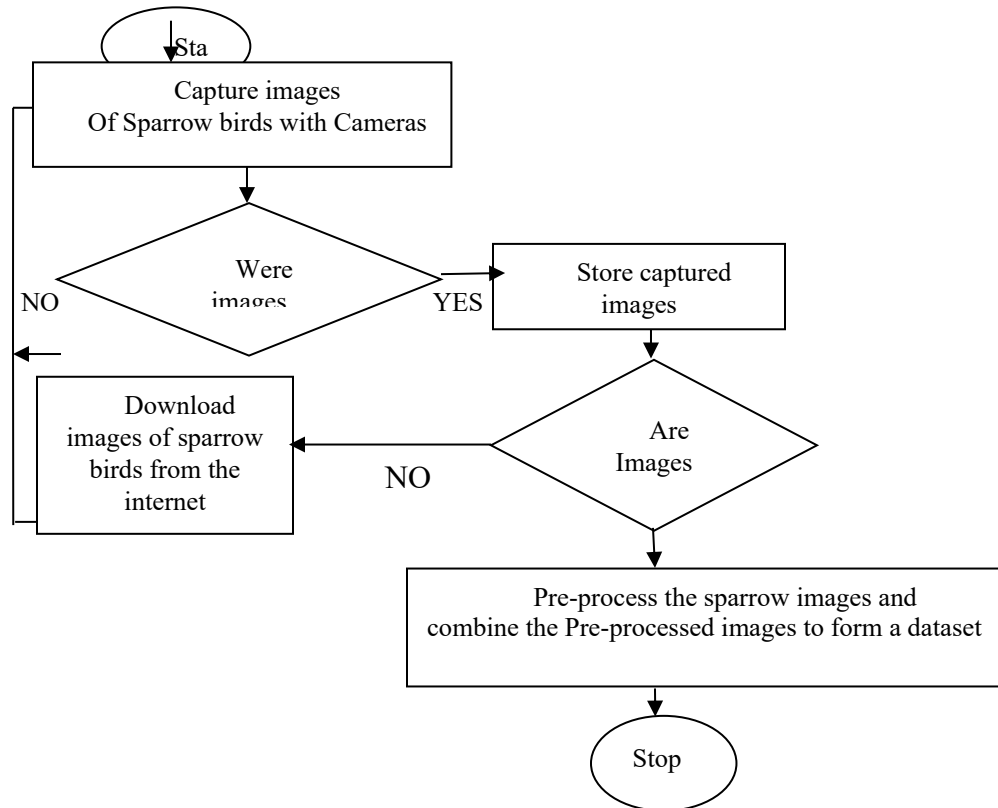


Fig. 1: Flowchart for building of training dataset for CNN model training

4.2 Model Development and Training

In the development of this convolutional neural network (CNN), a pre-trained high- efficiency model called efficientnetb5 was frozen with its weight and used in a process of transfer intelligence as a foundation for the new CNN model. (Probavathi and Kanmani 2021). The model development flow chart was shown in figure 2.

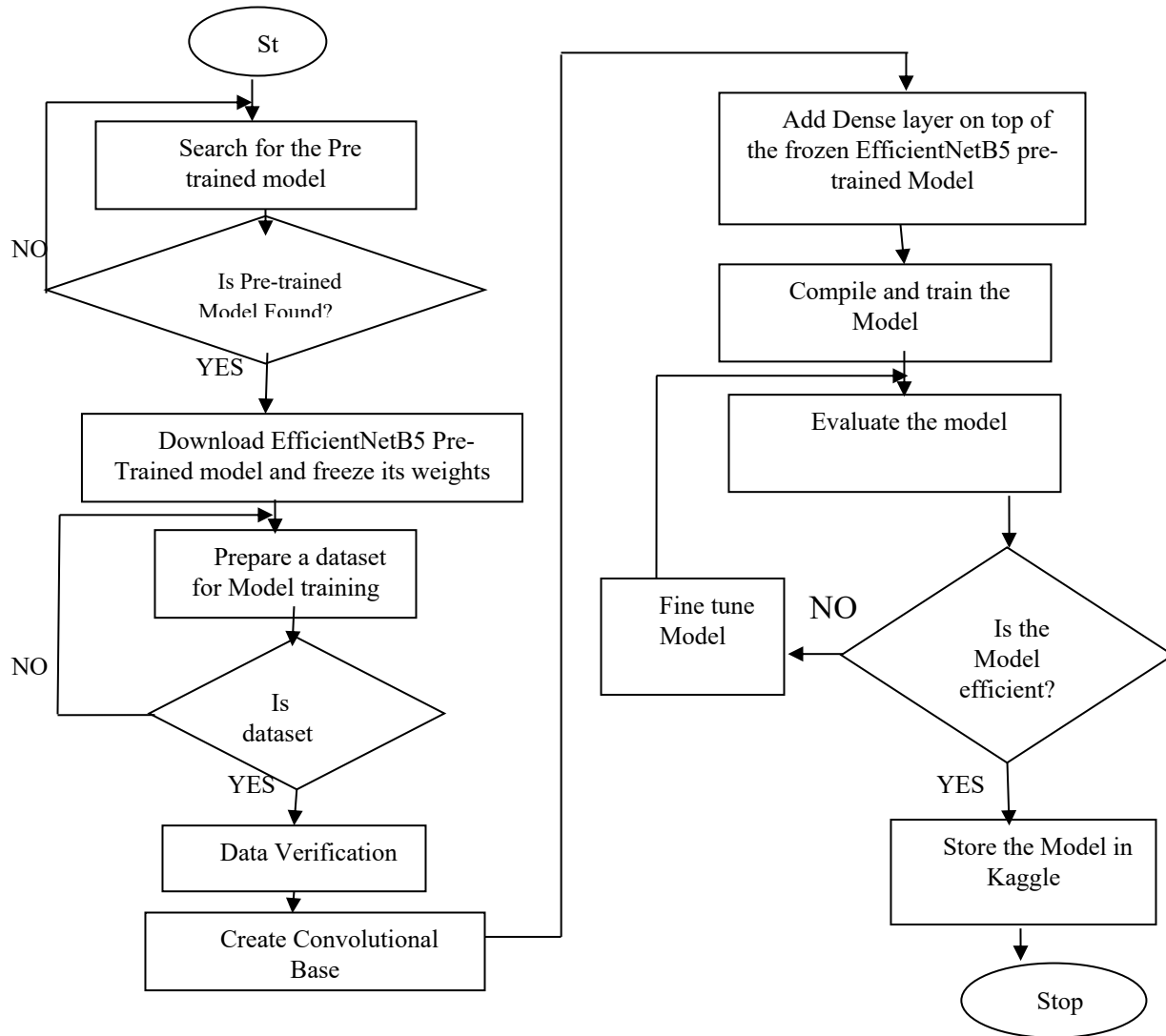


Fig. 2: Flowchart for building of CNN model for monitoring of harmful sparrow birds in a rice farm

The flowchart in Figure 2 was followed to produce the CNN model in Figure 3 which showed the sequence of the convolutional neural network (CNN) model developed in the course of this research with increased number of trainable parameters due to augmentation, dropout and unfreezing of the weights of the pre-trained efficientnetb5 model used as the foundation of the building of this model.

Layer (type)	Output Shape	Param #
InputLayer (InputLayer)	[(None, 224, 224, 3)]	0
AugmentationLayer (Sequential)	(None, None, None, None)	0
efficientnetb5 (Functional)	(None, 2048)	28513527
dense_3 (Dense)	(None, 1024)	2098176
activation_2 (Activation)	(None, 1024)	0
batch_normalization_2 (Batch Normalization)	(None, 1024)	4096
dropout_2 (Dropout)	(None, 1024)	0
dense_4 (Dense)	(None, 512)	524800
activation_3 (Activation)	(None, 512)	0
batch_normalization_3 (Batch Normalization)	(None, 512)	2048
dropout_3 (Dropout)	(None, 512)	0
dense_5 (Dense)	(None, 525)	269325
activationLayer (Activation)	(None, 525)	0
Total params: 31411972 (119.83 MB)		
Trainable params: 31063421 (118.50 MB)		
Non-trainable params: 348551 (1.33 MB)		

Fig. 3: CNN model for sparrow birds identification and characterization to monitor sparrow birds' migration in a rice farm showing inputs and output layers with more trainable parameters

4.3 Model Training

The developed CNN model in Figure 3 was trained using back-propagation method in google colab platform with 85,000 images of sparrow birds (combined 100 images from the farm and 84900 images from other sources) as preprocessed by the flowchart in Figure 1 and python programme in Appendix II (Deepak et al 2017).

4.4 Development of the Algorithm for Harmful Bird Deterrent

The developed CNN model did the classification of the birds into harmful sparrow and beneficial birds, then; an algorithm was developed to use the CNN model for rice harmful birds' recognition to perform the deterrence as shown in figure 4.

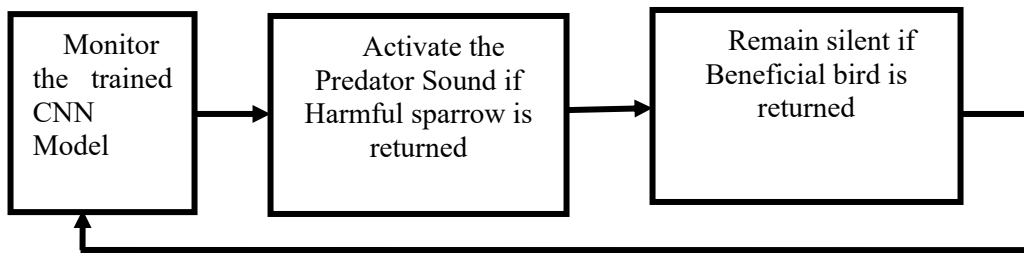


Fig. 4: Block diagram for bird deterrent using CNN model for harmful birds' recognition

5. Results and Discussions

5.1 Result of CNN Training

The results of the training of the developed CNN model in google colab platform and the image classification of the CNN model with the associated deterrent were simulated also using the Google Colab platform. Also table 1 and figure 5 showed the training and validation accuracies and losses.

Table 1: Training and validation accuracies and losses for the CNN model with epoch=20

Epoch Number	Training Accuracy	Training Loss	Validation Accuracy	Validation Loss
1/20	0.0573	5.7628	0.2731	4.0439
2/20	0.2440	4.0508	0.5829	2.6073
3/20	0.4573	2.8842	0.7657	1.5923
4/20	0.6284	2.0255	0.8484	0.9710
5/20	0.7362	1.4528	0.8899	0.6386
6/20	0.8004	1.0776	0.9139	0.4567
7/20	0.8448	0.8295	0.9242	0.3471
8/20	0.8733	0.6563	0.9387	0.2818
9/20	0.8946	0.5369	0.9459	0.2401
10/20	0.9087	0.4492	0.9531	0.1992
11/20	0.9227	0.3802	0.9562	0.1895
12/20	0.9331	0.3254	0.9554	0.1751
13/20	0.9412	0.2811	0.9688	0.1577
14/20	0.9486	0.2468	0.9684	0.1558
15/20	0.9547	0.2149	0.9642	0.1440
16/20	0.9599	0.1895	0.9646	0.1413
17/20	0.9648	0.1687	0.9669	0.1353
18/20	0.9683	0.1499	0.9653	0.1307
19/20	0.9708	0.1327	0.9638	0.1378
20/20	0.9749	0.1177	0.9669	0.1257

From the results in table 3, the developed CNN model to recognize sparrow birds in a rice farm has increased number of trainable parameters as shown in figure 3 which, after the training with dataset of 85,000 images of sparrow birds yielded very low training losses as shown in figure 5. Also, the validation loss was small with high validation and training accuracy of 97% as also shown in figure 5. This training was carried out in Google Colab platform with epoch of 20 and 85,000 preprocessed images of sparrow birds so as to obtain improved training and validation accuracies at highly reduced losses.

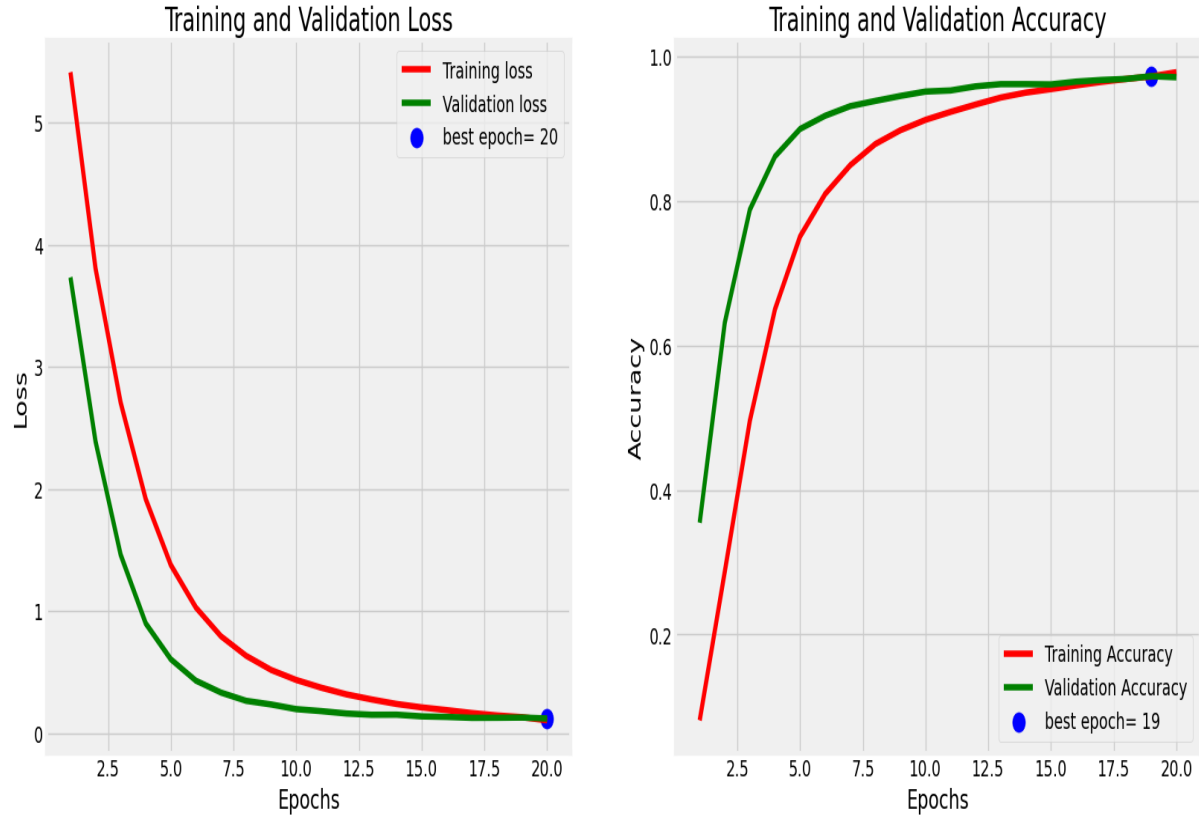


Fig. 5: Training and validation accuracies and losses of the developed CNN model for monitoring of sparrow birds.

5.2 Result of Beneficial Bird Classification in the Google Colab Platform

Figure 6 showed the result of the developed CNN model that classified a bird image fed into it as beneficial. Once the classification is beneficial, the deterrent algorithm does nothing so as to allow the beneficial birds to continue their biological pest control in the rice farm without any disturbance.

5.3 Result of Harmful Bird Classification in the Google Colab Platform

Figure 7 showed the result of the developed enhanced CNN model that classified bird images fed into it as harmful sparrow birds with associated predator sound that scared away the bird.



Fig. 6: Result of beneficial bird classification in google colab platform

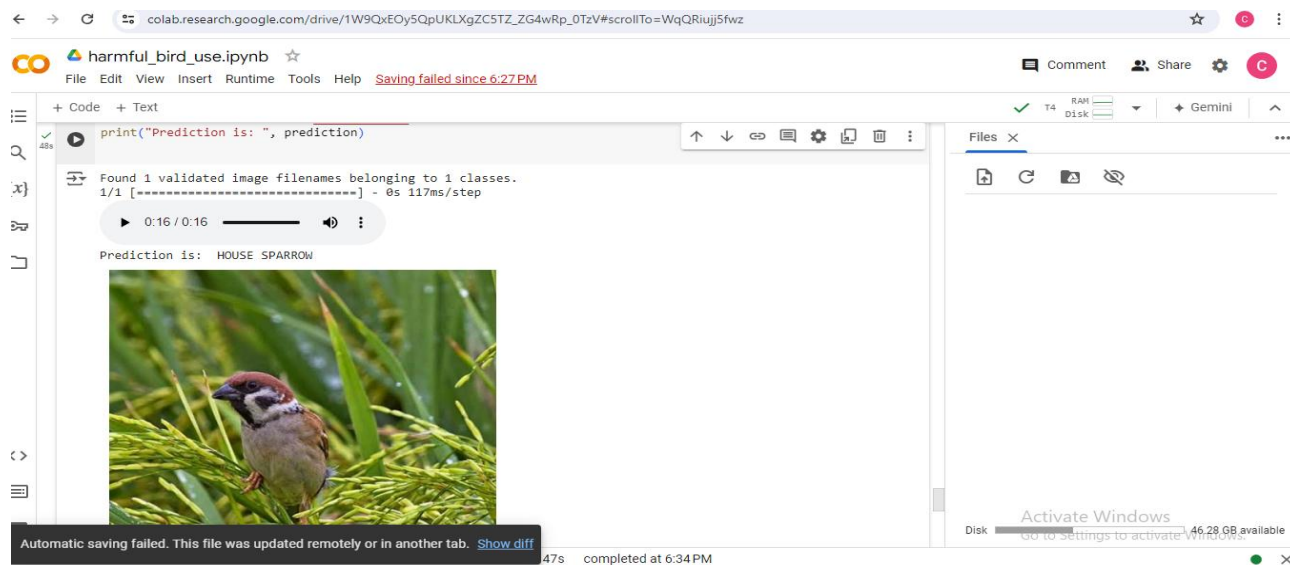


Fig. 7: Result of harmful bird classification in google colab platform

From the result of total predictions of 700 images of sparrow birds as shown in Figure 8, showing the true positives, true negatives, false positives and false negatives, the model parameters were determined as shown:

- Accuracy = 97.2%
- Precision = 96.5%
- Recall = 0.965
- F1 Score = 0.965

```

TP_predictions = Predictions1[(Predictions1["Test Classes"] == "HOUSE SPARROW") & (Predictions1["Prediction Classes"] == "HOUSE SPARROW")]
TN_predictions = Predictions1[(Predictions1["Test Classes"] != "HOUSE SPARROW") & (Predictions1["Prediction Classes"] != "HOUSE SPARROW")]
FP_predictions = Predictions1[(Predictions1["Test Classes"] != "HOUSE SPARROW") & (Predictions1["Prediction Classes"] == "HOUSE SPARROW")]
FN_predictions = Predictions1[(Predictions1["Test Classes"] == "HOUSE SPARROW") & (Predictions1["Prediction Classes"] != "HOUSE SPARROW")]
TN = TN_predictions.shape[0]
TP = TP_predictions.shape[0]
FP = FP_predictions.shape[0]
FN = FN_predictions.shape[0]
Total = Predictions1.shape[0]
print("Total Test: ", Total)
print("True Positive: ", TP)
print("True Negative: ", TN)
print("False Positive: ", FP)
print("False Negative: ", FN)

```

```

Total Test: 700
True Positive: 280
True Negative: 400
False Positive: 10
False Negative: 10

```

Fig. 8: Result of Model Testing

6. Conclusion

The developed Sparrow deterrent system used the bird classification into harmful sparrow and beneficial birds by the Convolutional neural network (CNN) model to scare away pest-sparrow birds using predator sound. When the model was used for predictions as shown in Figures 6 and 7 , it was able to give high accuracy (97.2%), precision(96.5%), recall(0.965) and F1score (0.965) of the model. Also in a Google Colab platform, the developed model was able to classify birds into harmful sparrow and beneficial (insectivorous) birds. It allowed the beneficial birds in 97% of their visits as shown in figure 6. Hence, it allowed the beneficial bird to continue its biological pest control without disturbances. However, when the model classification returned harmful Sparrow as shown in figure 7, it generated the sound of Squirrel which is the predator 97% of the times to scare them away. This was better than the 76% accuracy birds' classification obtained by a previous researcher (Oluwole, Adefemi and Ade-Omowaye 2020). This work should also be recommended for monitoring of migration of harmful birds and other animals across farms so as to reduce destruction of crops and improve harvest.

References

- Ankush, A., Arun, K. S., Sandeep, K., & Dharmendra, S. (2018). Critical analysis of classification techniques for precision agriculture monitoring using satellite and drones. In *2018 IEEE 13th International Conference on Industrial and Information Systems (ICIIS)*. IEEE. <https://doi.org/10.1109/ICIINFS.2018.8721422>
- Deepak, M., Akanksha, G., Tasneem, A., & Dharmendra, S. (2017). Fusion of drone and satellite data for precision agriculture monitoring. In *2016 11th International Conference on Industrial and Information Systems (ICIIS)*. IEEE. <https://doi.org/10.1109/ICIINFS.2016.8263068>
- Divyansh, C., & Patro, B. (2023). Real-time detection of birds for farm surveillance using You Only Look Once version 7 (YOLOv7). In *2023 3rd International Conference on Computing and Information Technology (ICCIT)*. IEEE. <https://doi.org/10.1109/ICCIT58132.2023.10273929>
- Ismael, D., Mouhamadu, L., & Amadou, D. G. (2023). Pest birds' detection approach in rice crops using pre-trained You Only Look Once version 4 (YOLOv4) detector and transfer learning. In *InterSol 2022: Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering* (Vol. 449). Springer. https://doi.org/10.1007/978-3-031-23116-2_19
- Marcon, D., Jiri, J., Josef, P., Josef, N., Eliska, V. H., Anna, S., Martin, C., Jana, L., Radim, K., Petr, R., Premysl, D., Miloslav, S., & Eva, G. (2023). A system using artificial intelligence to detect and scare bird flocks in the protection of ripening fruit. *Journal of the Faculty of Electrical Engineering and Communication*, 21(12), 4244. <https://doi.org/10.3390/521124244>

- Montràs-Janer, T., Knape, J., Nilsson, L., Tombre, I., Pärt, T., & Månsson, J. (2019). Relating national levels of crop damage to the abundance of large grazing birds: Implications for management.
- Nwonye, C. A., Akpado, K. A., Alumona, T. L., Oguejiofor, O. S., & Amaefule, D. O. (2024). Monitoring the migration of harmful sparrow birds in a rice farm using a convolutional neural network model. *UNIZIK Journal of Engineering and Applied Sciences*, 3(2), 1144–1162. <https://journals.unizik.edu.ng/index.php/ujeas>
- Oluwole, A., Adefemi, A., & Ade-Omowaye, J. (2020). A real-time image repellent system using Raspberry Pi. *FUOYE Journal of Engineering and Technology*, 5(2).
- O’Neal, B. A., Engel, D. R., & Frankenberger, J. R. (2020). Neural network prediction of maize yield using an alternative data-coding algorithm. *Biosystems Engineering*, 83(1), 31–46.
- Paolo, P. (2019, December 14). *Insights into agile methodologies for software development*. HackerNoon. <https://hackernoon.com>
- Pinowski, J., & Zaj, Z. R. (1990). *Damage to crops caused by birds in Central Europe*. PWN.
- Probavathi, S., & Kanmani, P. (2020). Plant leaf disease detection and classification using an optimized CNN model. *International Journal of Recent Technology and Engineering*, 9(6), 233–238.
- Ramesh, K. S., Srikanth, V., & Srinath, A. (2020). Crop surveillance using an unmanned aerial vehicle for precision agriculture. *International Journal of Innovative Technology and Exploring Engineering*, 9(8), 931–935. <https://doi.org/10.35940/ijitee.H6702.069820>