Evaluation Methods of Bird Repellent Devices in Optimizing Crop Production in Agriculture

Ahmad Roihan*[1], Muhaimin Hasanudin[2], and Endang Sunandar[3]

[1,3] Departement of Computer System, STMIK Raharja, Kota Tangerang, 15117, Indonesia.
[2] Departement of Information System, STMIK Raharja, Kota Tangerang, 15117, Indonesia.

*ahmad.roihan@raharja.info

Abstract. Rice field environments and bird attacks are the main problems for coverage and automatic pest control. Birds are one of several pests or destructive animals that can be found in rice fields. In general, farmers use traditional equipment such as plastic ropes and scarecrow to ward off these bird attacks. This research compares several methods of bird detection through camera sensors and chooses the best method in terms of accuracy, then applies it to repel birds automatically by utilizing sound frequencies that are disliked by birds and can repel bird pests. The design of the Bird repellent device works by utilizing computer vision techniques through camera sensors to capture bird objects in each frame, then it is processed by a microcontroller. After the object is captured on the camera, the microcontroller will activate the actuator in the form of sound frequency. The research objective is to design prototypes for the process of monitoring and automatic control of bird attacks to optimize crop yields in agriculture, based on the Internet of Things.

1. Introduction

The development of technology is getting faster and more sophisticated nowadays. Its sophistication is closely related to the development of supporting technologies such as sensors and actuator devices. The use of technology in agriculture is an important factor in the development of the food sector. Like reducing harvest time, technology also offers convenience provided by several research teams. Not only research on food technology in production, another problem that is raised in research is the problem of bird attacks [1].

The technique of repelling birds has actually been applied in several rice fields. Efforts that have been made by farmers are using traditional tools such as ringing clappers by going around rice fields, making scarecrows, then installing nets and detection devices for bird presence and how to expel them [2] [3]. Other recent research is observation of bird attacks both in wind fields [4] and around rice fields [5] and continues to be developed. Gradually, research on the use of sensor devices, actuators with microcontrollers is growing. Some of them are used in the monitoring process [6], measuring instruments [7], simulators [8], and so on.

The scope of research is limited to the evaluation of prototype devices called bird repellent devices. By utilizing artificial intelligence and utilizing computer vision, then accompanied by the application of object detectors such as YOLO and mask RCNN experiment which allows only with limited data knowledge, a computer can think like humans in dealing with some problems [9] such as bird attacks. The objectives to be achieved in this research are to get the best accuracy and speed values. Its value can be used as a comparison factor in object detection and can sterilize rice fields from bird pests. Surely it will facilitate the work of farmers and have a positive impact on the optimization of rice yields.

2. Method

Data collection methods used in this research consisted of observations, interviews and literature study. Therefore, research needs to visit rice fields in Labuan District as a research location to observe things or conditions that exist in the field. The question and answer process was held directly to the farmer groups and the task implementing team as resource persons and even data sources. Literature study method by reading the essence of literature sources such as books, articles and others related to this research, including references from the internet about object detection and image processing. The bird dataset we use from [10] can be prepared as a comparison with real time video later.

Design and development methods to get the right set of tools so that the prototype and design are obtained as expected [11]. The analytical method used in compiling research is the PDCA Cycle (Plan, Do, Check, Action). With this method allows the author to solve a problem that starts from gathering all the existing problems to determine and implement the solution. Furthermore, the Prototype method as a process of making a simple software model that allows users to have a basic picture of the program and conduct initial testing [12].

The precision evaluation method is based on a comparison of algorithm outputs or coordinate points in the form of bounding boxes covering objects detected with ground truth objects that have been manually created previously. The term of ground truth means reference data or annotation for comparison with object detectors [13]. After that, the test method was carried out experiments on bird repellent devices based on Raspberry Pi. RasPi is an SBC (Single board computer) the size of the most popular credit card based on the Linux operating system. Raspbian is an open source operating system derived from the Debian operating system [14].

As an evaluation material, we made several experiments using labeling techniques with the application labelImg. This results in the form of annotation which is used as a comparison on the object detector. Figures 1a and 2a are labeling results using labelImg. The object detector is able to produce the bounding box coordinates of an object in an image or video and does not tell us about the actual shape of the object itself. The object detector produces four sets of coordinate points (xmin, ymin, xmax, ymax) that represent the boundary box of an object in an image or video. The bounding box of an object obtained is a good start but the bounding box itself does not provide any information about which pixels belong to the foreground object as Regoin of Interest (RoI) and which pixels belong to the background. Evaluation is carried out using the mAP value of each experiment. The value of mAP for object detection is the mean Average Precision calculated for all detected classes. It is also important to note that for some papers, they use AP and mAP interchangeably. It is based on the Intersection over Union (IoU) across all classes in our dataset

In recent years, deep learning techniques achieve sophisticated results for object detection, such as in standard benchmark datasets and in computer vision competitions. Object detection is a task in computer vision that involves identifying existing and none, position, location, and types of one or more objects in an image or video. This is a challenging problem that involves the development of methods for object recognition (eg where they are), localization of objects (eg how wide they are), and classification of objects (eg what they are). Noteworthy is You Only Look Once or YOLO [15], a family of Convolutional Neural Networks that has now achieved the most sophisticated results with a single end-to-end model that can detect objects in real-time. Then the Mask R-CNN algorithm was introduced by He et al. in [16]. Mask R-CNN is built on previous object detection works from R-CNN [17], Fast R-CNN [18], and Faster R-CNN [19].

3. Results and Discussion

The need for supporting tools in solving problems is needed. Tools are systematic, support automation and utilize artificial intelligence have a function as something that can think like humans [20]. In the process of evaluating the system in automatic object detection required mAP as a reference value. Precision and recall are two commonly used metrics to assess the performance of a given classification model. To get the value of mAP, we need to review the values of precision and recall. The accuracy of certain classes in the classification is a positive predictive value, given as a ratio of true positive (TP) and the total number of positive predictions. Whereas recall is a true positive level or sensitivity, from the class given in the classification, defined as the ratio of TP and total positive of ground truth.

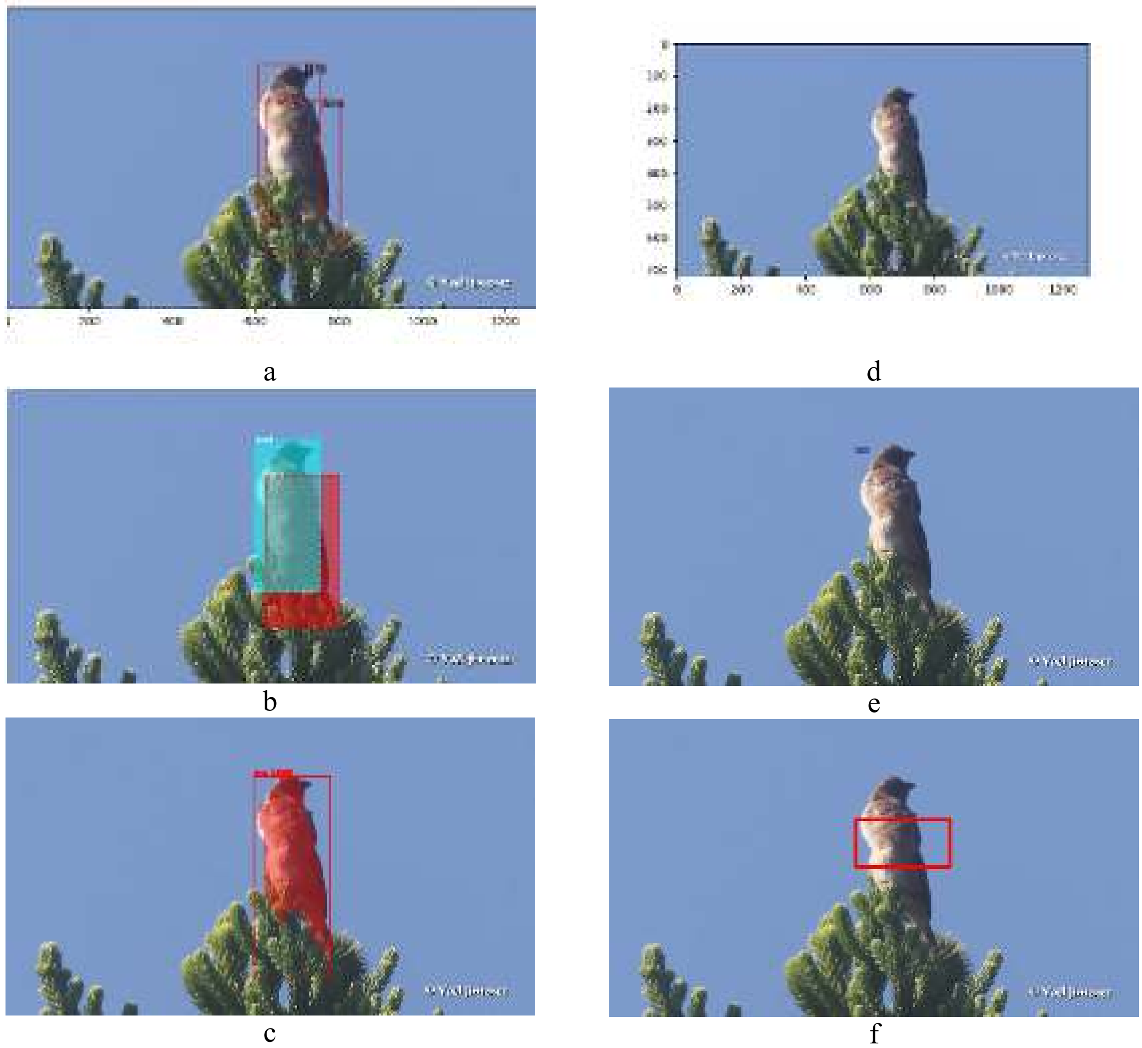

Figure 1. 175th frame **a.** The results of making annotations with labelImg **b.** The results of the conversion labelImg annotation into mask RCNN form **c.** The results of detection using the mask RCNN **d.** Results from detection using Keras YOLO V3 **e.** The results of detection using PyTorch YOLO V3 **f.** The results of the detection use the HaarCascade [21] classifier.

The research uses Anaconda to facilitate the creation of an environment for the installation process of supporting applications such as Tensorflow, Opencv, Keras and other supporting libraries. It also simplifies and speeds up performance in the system evaluation process by using a CPU. Earlier, the dataset we tested only gave annotations to 34 frames from a total of 834 frames from video [10]. Then we display the results in 2 parts of the frame, the 175th frame in Figure 1 and the 400th frame in Figure 2.

Figure 1 shows some of the successful and failed bird detection trials in the 175th frame. This is to indicate whether the object detector is able to capture bird objects in the state of Figure 1c which shows the Dog class instead of Bird. Parts in Figure 1e birds were detected and in Figure 1f birds were detected but accompanied by a bounding box with a level of confidence that is not too good. Whereas Figure 1d cannot detect anything.

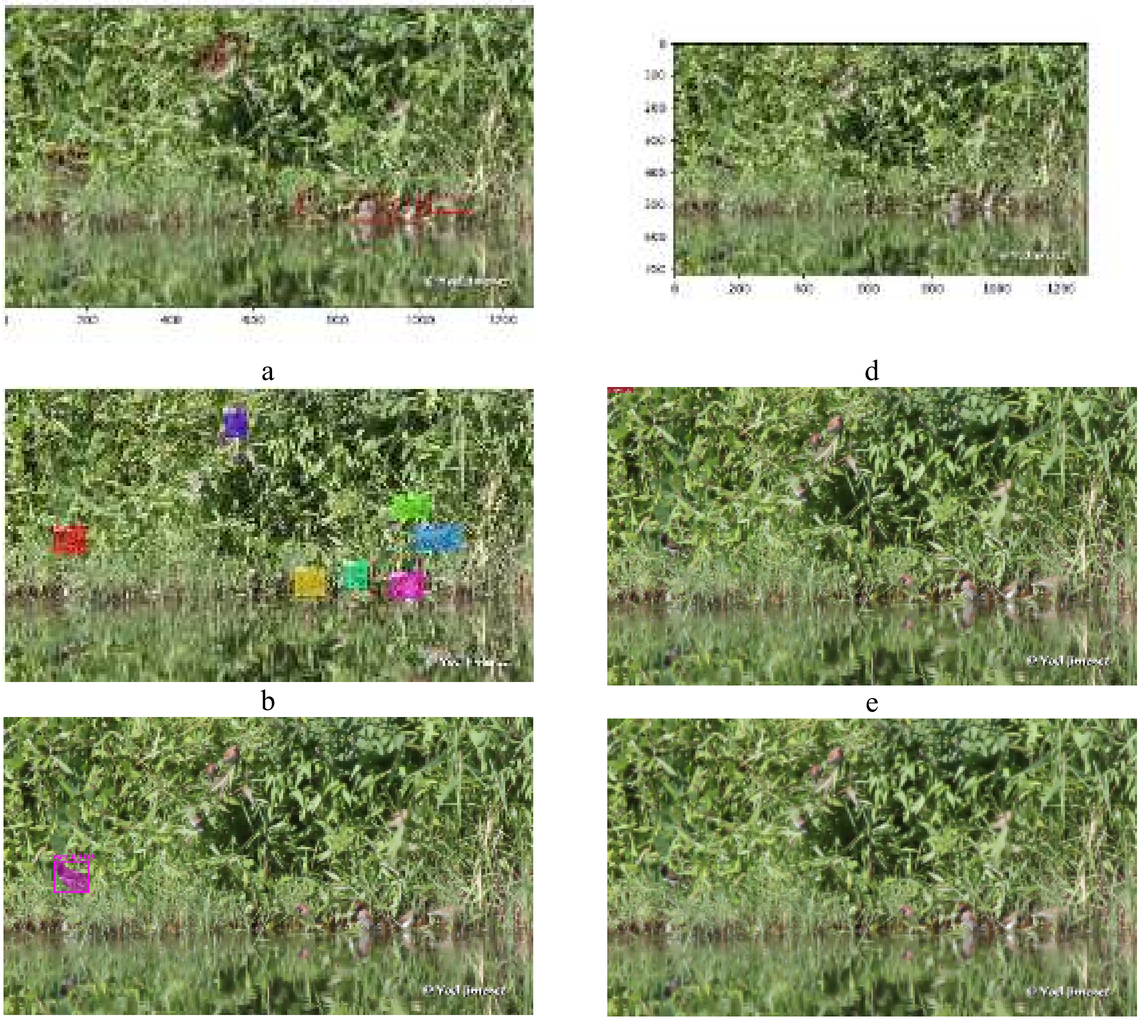

Figure 2. 400th frame **a.** The results of making annotations with labelImg **b.** The results of the conversion labelImg annotation into mask RCNN form **c.** The results of detection using the mask RCNN **d.** Results from detection using Keras YOLO V3 **e.** The results of detection using PyTorch YOLO V3 **f.** The results of the detection use the HaarCascade [21] classifier.

Figure 2 shows some of the successful trials and failures of bird detection in the 400th frame. This is to test how accurate the object detector is at capturing the image of many birds with a background clutter state. In the Figure 1c section which shows one Bird. The section in Figure 1e delimiters shows all frames included in the person class. Whereas Figure 1d and 1f cannot detect anything.

The two parts of the Figure in the 175th and 400th frames show that there are at least two fundamental differences between the classification and detection of objects from images or videos for example from one image input in the classification, the algorithm will insert them into the network and get one class label that appears. Conversely when doing it in object detection, the results can display multiple bounding boxes and class labels. Because the detection results in the mask RCNN will always get only a class and YOLO will detect many classes. Therefore, we only present mAP values in Figures 3 and 4 of the two differences.

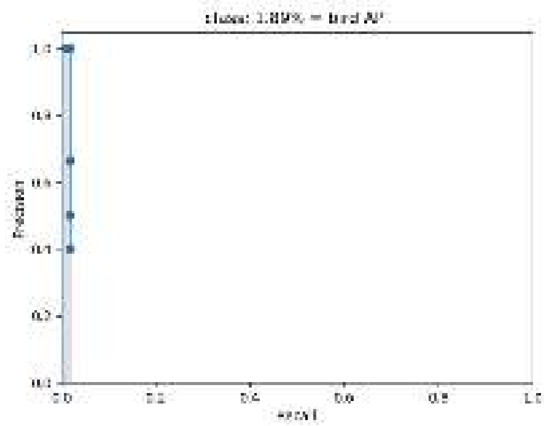

Figure 3. mAP Result from PyTorch YOLO V3

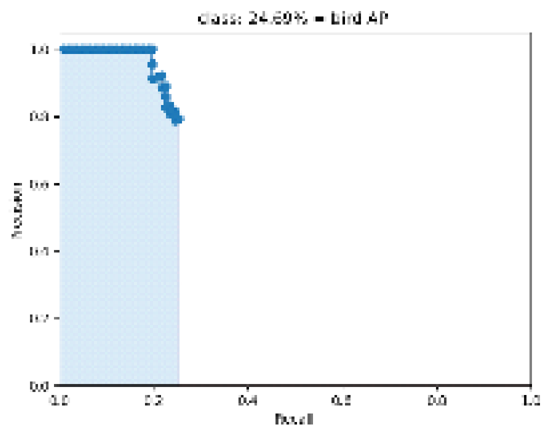

Figure 4. mAP Result from Mask RCNN

Research opportunities revolve around developing the accuracy and precision of object detection, then measuring the effectiveness of the actuator in acting as a bird eviction technique and counting the number of birds that have been detected so that it can be used as a decision support element. The vast area of rice fields also makes an important factor in building a wireless sensor network [22] like a camera sensor in monitoring in the pedestrian in order to support the development of industry 4.0 in agricultural areas.

4. Conclusion
This research is in line with the vision of the farmer groups. Its vision is that at harvest time they have abundant yields without disturbances such as bird attacks. The extent of the rice field environment becomes a big problem in camera sensor capture in the process of object detection. In addition, bird attacks are also a major problem for automatic pest control. Birds are one of the few pests in the field. The use of traditional equipment such as plastic ropes and scarecrow to ward off bird attacks has not yet exploited developed technology. Therefore, this study designed a tool and compared several bird detection methods through camera sensors and chose the best method in terms of accuracy, then applied it automatically by utilizing sound frequencies to repel bird pests. Based on experiments obtained significant results in terms of speed and accuracy using Pytorch YOLO V3 and RCNN masks. The design of anti-bird devices works by utilizing computer vision techniques through camera sensors to capture bird objects in each frame. After the object is detected by the camera sensor, the microcontroller activates the actuator in the form of sound frequencies. The aim of the research is to design a prototype for the process of automatically monitoring and controlling bird attacks to optimize crop yields on agriculture, based on the Internet of Things [23].

This prototype consists of the Raspberry Pi as the main controller for bird repellent device connected to the camera sensor as input and the speaker as the actuator. The system that was built is certainly still in the development stage to be better. The selection and evaluation of the object detector is a more advanced step after the system design stage. There are several other problems that certainly need to be investigated both from computing capabilities to the process of communication to the cloud.

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References
[1] Y. Wei, H. Liu, J. Shu, and B. Shi, "Design of agricultural aircraft with audio anti-bird," in *2015 Fifth International Conference on Instrumentation and Measurement, Computer, Communication and Control (IMCCC)*. IEEE, 2015, pp. 81–85.
[2] X. Meng, W. Zheng, F. Chen, Z. Xing, C. Shen, and G. Sun, "The device of ultrasound driving bird," in *2010 World Automation Congress*. IEEE, 2010, pp. 83–86.
[3] A. Muminov, Y. C. Jeon, D. Na, C. Lee, and H. S. Jeon, "Development of a solar powered bird repeller system with effective bird scarer sounds," in *2017 International Conference on Information Science and Communications Technologies (ICISCT)*. IEEE, 2017, pp. 1–4.
[4] A. Takeki, T. T. Trinh, R. Yoshihashi, R. Kawakami, M. Iida, and T. Naemura, "Combining deep features for object detection at various scales: finding small birds in landscape images," *IPSJ transactions on computer vision and applications*, vol. 8, no. 1, p. 5, 2016.
[5] Z. Chen, Q. Zhou, J. Liu, L. Wang, J. Ren, Q. Huang, H. Deng, L. Zhang,and D. Li, "Charms-china agricultural remote sensing monitoring system," in *2011 IEEE International Geoscience and Remote Sensing Symposium*. IEEE, 2011, pp. 3530–3533.
[6] A. Roihan, A. Permana and D. Mila, "Monitoring Kebocoran Gas Menggunakan Mikrokontroler Arduino UNO dan ESP8266 Berbasis Internet of Things," *ICIT (Innovative Creative and Information Technology)*, vol. 2, no. 2, pp. 170-183, 2016.
[7] I. A. Supriyono, F. Sudarto, and M. K. Fakhri, "Pengukur tinggi badan menggunakan sensor ultrasonik berbasis mikrokontroler atmega328 dengan output suara," *CCIT Journal*, vol. 9, no. 2, pp. 148–156, 2016.
[8] A. Roihan, P. A. Sunarya, and C. Wijaya, "Auto tee prototype as tee golf automation in golf simulator studio," in *2018 6th International Conference on Cyber and IT Service Management (CITSM)*. IEEE, 2018, pp. 1–5.
[9] S. Sutrisno, D. P. Kristiadi, and D. Supriyanti, "Aplikasi sistem pakar untuk mendiagnosa gangguan jaringan lan berbasis android di sekolah kemurnian jakarta," *SENSI Journal*, vol. 3, no. 2, pp. 221–239, 2017.
[10] Y. Jimenez, "Video of Scaly-breasted Munia Lonchura punctulata at Cibodas Botanical Gardens, Java," *IBC1224278*, 2014. [Online]. Available: *hbw.com/ibc/1224278*
[11] Ilamsyah, H. I. Setyawan, and A. Syahfitri, "Robot pencari benda menggunakan perintah suara berbasis arduino uno,"CERITA Journal, vol. 3,no. 2, pp. 206–216, 2017.
[12] P. A. Sunarya, A. Roihan, D. Aryani, and A. Rifa'i, "Warning button crime system in supporting the management of public services in the legal area of polres kota tangerang," *Journal of Physics: Conference Series*, vol. 1179, p. 012017, jul 2019. [Online]. Available: https://doi.org/10.1088/1742-6596/1179/1/012017
[13] M. Szczodrak , P. Dalka , A. Czyżewski, "Moving object tracking algorithm evaluation in autonomous surveillance system," in *Proceedings of the 2nd International Conference on Information Technology, ICIT,* pp. 31-34, 2010.
[14] W. Harrington, "Learning Raspbian," *Packt Publishing Ltd*, UK, 2015.
[15] J. Redmon and A. Farhadi, "Yolov3: An incremental improvement," *CoRR*, vol. abs/1804.02767, 2018. [Online]. Available:http://arxiv.org/abs/1804.02767
[16] K. He, G. Gkioxari, P. Dollar, and R. Girshick. "Mask R-CNN," *arXiv:1703.06870*, 2017.
[17] R. Girshick, J. Donahue, T. Darrell, and J. Malik, "Rich feature hierarchies for accurate object detection and semantic segmentation," in *Proc. CVPR*, Jun. 2014, pp. 580–587.
[18] R. Girshick, "Fast R-CNN," in *Proc. ICCV*, Dec. 2015, pp. 1440–1448
[19] S. Ren, K. He, R. Girshick, and J. Sun, "Faster R-CNN: Towards realtime object detection with

region proposal networks," in *Proc. NIPS*, 2015, pp. 91–99.
[20] A. Sunarya, S. Santoso, and W. Sentanu, "Sistem pakar untuk mendiagnosagangguan jaringan lan," *CCIT Journal*, vol. 8, no. 2, pp. 1–11, 2015.
[21] K. Yenusu "OpenCV-Birds-Detection-Algorithm," 2018. [Online]. Available: https://github.com/yenusu/OpenCV-Birds-Detection-Algorithm
[22] D. Wu, J. He, H. Wang, C. Wang, and R. Wang, "A hierarchical packet forwarding mechanism for energy harvesting wireless sensor networks," *IEEE Communications Magazine*, vol. 53, no. 8, pp. 92–98, August 2015.
[23] A. Roihan, F. Sudarto, and T. C. Putro, "Internet of things on monitoringand control system in server area," in *2018 International Seminar on Application for Technology of Information and Communication*. IEEE, 2018, pp. 116–120.