Implementation of Deep Learning Using YOLOv7 and Telegram Notifications for Preventing Illegal Fishing in the Sea of Batam

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Abstract

Batam Island is one of Indonesia’s outermost islands that directly borders neighboring countries. The implementation of YOLOv7 to detect ships in the Sea of Batam is capable of identifying ship objects, with test results after 100 training epochs producing a precision value of 1.00 and a confidence value of 0.882, indicating a high level of confidence in the detection results of the YOLOv7 model. The F1 score of 0.99 at a confidence level of 0.729 shows that this model achieves a high level of accuracy in object detection. Based on the evaluation results using a confusion matrix, it indicates high accuracy for each class in the YOLOv7 model: Ferry 93%, KapalNelayanIndonesia 85%, KapalNelayanMalaysia 89%, KapalNelayanThailand 91%, KapalNelayanVietnam 82%, Speedboat 94%, and Tanker 83%. The testing results of the website application integrated with YOLOv7 and Telegram bot produce a website that can detect objects and send notifications, thus expected to prevent illegal fishing.

Keywords

Detection, Deep Learning, Ship, Telegram, YOLOv7
A. Introduction

President Joko Widodo’s speech at the 5th Our Ocean Conference in Nusa Dua Bali in 2018 said that Indonesia plays an important role in the maritime industry. The President emphasized that Indonesia is a maritime country where most of Indonesia’s territory consists of the sea, and the sea also provides life for millions of people in this world. Around 90% of total world trade travels by sea, because of the importance of maritime functions, maritime crimes are increasing, such as piracy, drug smuggling, human trafficking, and illegal fishing [1]. Indonesia’s marine areas have abundant fish resources, which makes fishermen from foreign countries interested in these resources by carrying out illegal fishing activities. Illegal fishing is an activity carried out by foreign fishermen who enter Indonesian seas illegally to catch fish [2].

Advances in image recognition technology and video analysis using Artificial Intelligence (AI) are becoming increasingly widespread. Poor image coding can cause image recognition accuracy to decrease. This research proposes an artificial neural network method to improve image recognition accuracy, especially object detection accuracy by applying post-processing to videos coded using VVC (Versatile Video Coding). Test results show that the combination of the VVC and YOLOv7 methods produces high object detection accuracy [3]. The YOLO (You Only Look Once) algorithm is an algorithm capable of detecting targets based on deep learning and Convolutional Neural Networks (CNN). The advantages of this algorithm include high speed, high detection accuracy, and can monitor objects in real-time. The test results produced an optimal performance for detecting steel production defects with mAP (Mean Average Precision) values of 80.2% in training testing and 81.9% in testing data [4].

The impact of the Covid 19 pandemic has been felt throughout the world, resulting in the issuance of regulations on wearing masks and maintaining distance in public areas. The authorities have taken various preventive measures to prevent people from not wearing masks. It isn’t easy to check masks in crowded areas such as schools, hospitals, and malls, so technology is needed to detect people wearing and not wearing masks. In this research, one of the deep learning algorithms, namely YOLOv7, was used. The results of this research show that YOLOv7 can differentiate between people wearing masks, not wearing masks, and wearing masks incorrectly [5]. Research on the INSURE (Unlicensed and Unreported Fishing) system that uses Earth observations from satellites and AIS data has proven efficient in monitoring and detecting illegal fishing activities in West Africa, which cause material losses and damage to coastal and marine ecosystems, with deep learning methods. detection success reached 91% [6].

By using computer vision technology, CV-DMA, and YOLO research has helped Brazilian maritime authorities integrate ship records and camera images to improve maritime security, facing the threat of illegal activities such as drug trafficking and illegal fishing [7]. Fish cultivation using aquaculture methods relies heavily on accurate fish detection processes underwater so that fish behavior can be determined. Underwater environmental conditions are influenced by lighting and water quality so that they covers the fish’s body. Therefore, underwater fish are not very clear, limiting the accuracy of underwater target recognition.
Experimental results show that the detection accuracy of the YOLOv7 model is 92.86% [8].

By combining the IDOD module with YOLOv7 aimed at increasing detection accuracy, this research succeeded in improving object detection in low-light foggy weather environments, as evidenced by experimental results showing increased image quality and objective evaluation, as well as improving perception in autonomous driving in these conditions [9]. Telegram notifications are a medium for sending messages, images, videos, documents, and other types of files. The API used in Telegram is open source which helps developers to create their own Telegram applications [10].

B. Research Method

Ship detection research using YOLOv7 and Telegram chat notifications in this research consists of seven stages, namely: Dataset, Data Preprocessing, Data Labeling, YOLO v7 Model, Model Evaluation, Python Flask, and Telegram Notification. These seven stages are used to obtain ship detection results as in Figure 1.

![Diagram Block System](image-url)
Dataset
A dataset is a collection of images used for the model training and evaluation process so that it becomes an important part of the object detection and object classification process in the YOLO algorithm [11]. The dataset used is ship images consisting of ferries, fishing boats, speed boats and tankers as in Figure 2.

Figure 2. Ship Imagery

Data Preprocessing
In this data preprocessing process, cropping will be carried out on the ship image with the aim of simplifying the training process for the YOLOv7 model. The cropping process functions to obtain important areas so that there are no unimportant parts that hinder the training process [12].

Data Labelling
Labeling is the process of giving labels or tags to objects in the image. In the labeling process, the object name, object class, and information useful for the training process for object detection in images will be determined as in Figure 3 [13].

Figure 3. Labelling

YOLO Model
YOLOv7 is the latest model of the YOLO detection algorithm. It has surpassed all other object detectors in terms of detection speed and accuracy, achieving a range from 5 FPS to 160 FPS. Furthermore, it boasts the highest accuracy of 56.8%
AP among all real-time object detectors running at 30 FPS on a GPU V100, as shown in Figure 4.

![Figure 4. Detector Comparison [14].](image)

Figure 5 shows how YOLOv7 works overall. The input image will be resized to 640 x 640 before entering the backbone. In the head network layer, there are REP and conv which are used to display prediction results.

![Figure 5. YOLOv7 Framework [15].](image)

**Evaluation Model**

The model evaluation process aims to determine the accuracy of the prediction and classification results on the input image. There are several ways to evaluate classification, namely confusion matrix, precision, and recall. Confusion matrix is used to evaluate classification results. Table 1 displays the Confusion Matrix results, including True Negative (TN), True Positive (TP), False Negative (FN), and False Positive (FP) [16].

![Table 1. Confusion Matrix](image)

**Python Flask**
Flask is a website framework written in the Python programming language. The way Flask works does not require any specific libraries and has a built-in database. Flask also supports several extensions, namely object-relational mappers, form validation, and upload handling [17].

**Telegram Notification**

Telegram features bots capable of automatically sending messages. A bot, in this context, refers to a program hosted on the Telegram server. To obtain information, one can use the Telegram client installed on the mobile device of the server administrator. The Telegram client acts as an interface that presents specific information. The process of sending and receiving information through Telegram is illustrated in Figure 6.

![Telegram Notification Diagram](image)

**Figure 6. Sending and Receiving Information [18]**

**Software Design**

Figure 7 is a use-case diagram of the system to be created. There are 5 use cases, namely, ship detection results and telegram notifications that can be carried out by telegram users. Meanwhile, admins can log in, user management, and ship detection with the condition that the admin must log in first.

![Software Design Diagram](image)

**Figure 7. Use Case Diagram**
C. Result and Discussion

Dataset management in this research uses photo data taken from a Canon 80D camera at the locations of Sekupang Harbor, Harbor Bay, Batam Center Harbor, and Belakang Padang for photos of Ferry, Speedboats, and Tankers. Meanwhile, photos of KapalNelayanMalaysia, KapalNelayanThai, and KapalNelayanVietnam were obtained from www.kaggle.com. The YOLOv7 dataset used in this research consists of 700 images used for the training set process, 140 images for validation, and 35 images for the testing set process. The training set is the process of training the YOLOv7 model so that it can predict the whereabouts of ship objects. The validation set serves to assess the performance of the YOLOv7 model during the training process. Meanwhile, the testing set process functions to test the YOLOv7 model when managing images. The dataset used in this research is divided into seven classes, namely the Ferry class, KapalNelayanIndonesia, KapalNelayanMalaysia, KapalNelayanThailand, KapalNelayanVietnam, Speedboat, and Tanker. The class grouping used in the dataset can be seen in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Class</th>
<th>Number of Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ferry</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>KapalNelayanIndonesia</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>KapalNelayanMalaysia</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>KapalNelayanThailand</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>KapalNelayanVietnam</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Speedboat</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Tankers</td>
<td>100</td>
</tr>
</tbody>
</table>

The data in Table 2 shown above shows the number of image samples that will be processed to become training data so that the system can detect ship types from various classes. The number of images that will be sampled is 100 image data in each class that has gone through a labeling process.

Training Model YOLOv7

The training process in this research utilized Google Colab and Python, employing a dataset of 875 images. This dataset comprised 700 images for the training set, 140 images for the validation set, and 35 images for the testing set process. The training spanned 100 epochs with a batch size set to 16, and the input image size was configured to 640x640. The training results are illustrated in Figure 8.
Figure 8. Training Data Results

Figure 9 shows the graphic relationship between precision and confidence. Precision functions to show the quality of the YOLOv7 model when classifying objects. Precision also measures the YOLOv7 model to provide correct values when the process provides labels to detected objects. Confidence is the value of the YOLOv7 model’s level of confidence in the correctness of the label given to the detected object. The precision value in this study, namely 1.00, proves that the YOLOv7 model is correct when labeling the detected objects. The confidence value of 0.882 indicates that you are quite confident in the label given to the detected object.

Figure 9. Precision and Confidence
Comparison of recall and confidence values in Figure 10 to identify how accurate the YOLOv7 model is in explaining the data. A recall value of 1.00 for all classes at a confidence level of 0 indicates that the YOLOv7 model has a significant level of identification with the data.

![Figure 10. Recall and Confidence for All Classes](image1)

Based on the results obtained, the F1 score is 0.99 with a confidence of 0.729 for all classes. The F1 score is employed to assess the performance of the YOLOv7 model in object detection. Consequently, the average precision of the model in identifying actual objects in the image is 99%. This shows that the model has a high level of accuracy in finding objects in the image as in Figure 11.

![Figure 11. F1 Score](image2)
Confusion matrix is a metric used to evaluate the YOLOv7 model when detecting objects. This matrix functions as a grouping of objects in the image. Each row shows a class in YOLOv7, while the column shows the predicted class. Figure 12 shows the confusion matrix results from the YOLOv7 model in detecting ship types.

![Confusion Matrix](image)

**Figure 12. Confusion Matrix**

TP (True Positive) results show the number of objects that can be detected by the YOLOv7 model. With a high TP value, the better the model's performance in grouping objects in the image. Figure 12 also shows the results of the FP (False Positive) background in the KapalNelayanIndo and KapalNelayanThailand classes, namely 0.5, this value shows that the model detects the background of the image. The results of the confusion matrix, depicted in Figure 12, illustrate the accuracy level of ship detection, as summarized in Table 3.

<table>
<thead>
<tr>
<th>No</th>
<th>Class</th>
<th>Accuracy Detection</th>
<th>Background (False Positive)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ferry</td>
<td>93%</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>KapalNelayanIndo</td>
<td>85%</td>
<td>50%</td>
</tr>
<tr>
<td>3</td>
<td>KapalNelayanMalaysia</td>
<td>89%</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>KapalNelayanThailand</td>
<td>91%</td>
<td>50%</td>
</tr>
<tr>
<td>5</td>
<td>KapalNelayanVietnam</td>
<td>82%</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Speedboat</td>
<td>94%</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. Accuracy of Each Class
Test result

Figure 13 shows the results of the validation of the YOLOv7 model. The figure shows that the YOLOv7 model used has succeeded in detecting ship objects according to their respective classes.

Gambar 13. Model Validation Results (a) KapalNelayanIndonesia (b) KapalNelayanVietnam (c) Speedboat

System Implementation and Testing

After carrying out the training process, the YOLO model will save the best results from the training process in the form of the "best.pt" format. The results of best.pt will be integrated into the ship detection application. The Python Flask framework can integrate between YOLOv7 and applications. Flask is a website framework using the Python programming language that can create simple website applications. Flask can create an application that can receive input and produce output according to user needs. To send detection results images to Telegram, use the Python library, namely Teleport. Teleport is part of the Python library which functions to integrate the Telegram API with applications. Telegram functions to send notifications, messages, and content via Telegram. The features available on Teleport can be used to control bots on Telegram. Figure 14 shows the results of integration testing between the flask website and YOLOv7.
System test results can be accessed via a browser so they can be viewed using smart devices such as tablets, laptops, and smartphones connected to the internet network. Figure 15 shows the results of the notification for sending detected images via chatbot on the Telegram platform. The image sent is the result of training from the YOLOv7 model that was created previously.

**Figure 14.** Flask and YOLOv7 integration

**Figure 15.** Telegram Notifications
The application of Flask integrated with the YOLOv7 model can provide a solution for detecting ships in the Batam Sea. Implementation of a telegram bot as a sender of notification of ship detection results can prevent illegal fishing in the Batam Sea.

D. Conclusion
Based on the results of ship detection research using YOLOv7, it is able to detect types of ships based on predetermined classes. The detection results after 100 epoch training produced a precision value of 1.00 and a confidence value of 0.882 indicating a high level of confidence in the detection results in the YOLOv7 model. The F1 score of 0.99 at confidence 0.729 shows that this model produces a high level of accuracy in finding objects. Based on the evaluation results using the confusion matrix, it shows high accuracy results for each class in the YOLOv7 model, namely Ferry 93%, KapalNelayanIndonesia 85%, KapalNelayanMalaysia 89%, KapalNelayanThai 91%, KapalNelayanVietnam 82%, Speedboat 94%, and Tanker 83%. In testing an application that integrates the YOLOv7 model with the Python Flask framework, it produces a website application that can detect objects. The test results show that the Telegram bot is able to send notifications automatically to the Telegram platform if a ship object is detected. By implementing this system, it is hoped that it can increase the prevention of illegal fishing in the Batam Sea, which is an island that directly borders neighboring countries.

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F. References


