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Object Detection of Track Using YOLO Method in Fast Unmanned Vessel Application

RA. Diva Arta Mevia Putri Winarno[1*], Elmi Hidayana [1], Anggara Trisna Nugraha [2], Epyk Sunarno[3]

[1]*Department of Automation Engineering, Shipbuilding Institute of Polythecnic Surabaya, Jalan Teknik Kimia ITS, Keputih, Kec. Sukolilo, Surabaya, Jawa Timur 60111*

[2] *Department of Marine Electrical Engineering, Shipbuilding Institute of Polythecnic Surabaya, Jalan Teknik Kimia ITS, Keputih, Kec. Sukolilo, Surabaya, Jawa Timur 60111*

[3] *Department of Electrical Engineering, Electronic Engineering Polythecnic Institute of Surabaya, Jalan Raya ITS, Keputih, Kec. Sukolilo, Surabaya, Jawa Timur 60111*

Abstrak. Metode YOLO (You Only Look Once) digunakan dalam pembacaan lintasan buoy melalui webcam, sebuah pendekatan deteksi objek berbasis deep learning yang unggul dalam kecepatan dan presisi. Dalam deteksi lintasan, citra digital diambil melalui kamera atau dataset dan diubah menjadi format matriks piksel yang dapat diterima oleh model CNN. Jaringan CNN kemudian mengekstraksi fitur dari citra untuk deteksi buoy merah dan hijau melalui operasi konvolusi, pooling, dan aktivasi. Sistem menggunakan pengklasifikasi objek yang dianalisis di berbagai lokasi dan skala pada gambar, dilanjutkan dengan post-processing untuk menyaring kotak pembatas dan menghilangkan deteksi ganda. Dengan webcam yang memiliki akses baik, tingkat akurasi pendeteksian buoy mencapai hampir 100%, terutama ketika buoy ditempatkan dekat dengan perangkat. Pengguna mendapatkan informasi real-time tentang objek-objek terdeteksi melalui tampilan webcam dengan menampilkan kotak pembatas pada objek tersebut. Metode YOLO berhasil mendeteksi buoy dengan akurasi sesuai dengan hasil dari proses pelatihan, mencapai rata-rata 41,42%. Sistem ini menunjukkan ketepatan dalam deteksi objek lintasan, memberikan kemampuan yang baik bahkan ketika webcam digunakan selama proses pelatihan dan labeling objek menggunakan metode YOLO.

Katakunci: Buoy, CNN, Pengolahan Citra, YOLO

Abstract. The YOLO (You Only Look Once) method is applied in tracking buoy paths through a webcam, representing an object detection approach based on superior deep learning capabilities in terms of speed and precision. In the path detection process, digital images are captured through a camera or dataset and converted into pixel matrix format acceptable to the CNN model. The CNN network then extracts features from the images to detect red and green buoys through convolution, pooling, and activation operations. The system utilizes an object classifier analyzed at various locations and scales in the image, followed by post-processing to filter bounding boxes and eliminate duplicate detections.

Email Korespondensi: anggaranugraha@ppns.ac.id
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With a well-accessed webcam, the buoy detection accuracy reaches almost 100%, particularly when the buoy is placed near the device. Users receive real-time information about detected objects through the webcam display by showcasing bounding boxes on these objects. The YOLO method successfully detects buoys with accuracy consistent with the training process results, achieving an average of 41.42%. This system demonstrates accuracy in tracking object paths, providing reliable capabilities even when the webcam is used during training and object labeling using the YOLO method.

Keywords: Buoy, CNN, Image Processing, YOLO.

Introduction

The Unmanned Fast Boat Consortium Competition (KKCTBN) is a robotic competition designed to assess the capabilities of unmanned fast boat robot technology in various aspects such as speed, navigation, and endurance. A robot is a device capable of performing tasks either under human control and supervision (remote) or using pre-programmed instructions (automatic) [1]. The primary focus of this competition is unmanned fast boats due to their significant potential in various sectors, including maritime exploration, marine research, and water security [2]. Unmanned fast boats have an advantage in reading tracks using digital image processing to detect obstacles.

One essential navigational aid for ships is a floating beacon, commonly known as a buoy. A buoy is a floating navigational aid that provides guidance to navigators regarding hazards or obstacles in navigation, such as coral reefs, shallow waters, shipwrecks, and indicates safe waters. It can also be used as a boundary marker for a country's territorial waters [3]. To read buoy obstacles, a webcam is used for track reading, and the method employed for reading is YOLO (You Only Look Once) image processing [4].

YOLO (You Only Look Once) is an object detection approach based on deep learning that utilizes a high-speed convolutional neural network (CNN) with excellent performance in recognizing objects with high precision [5]. This method has been successfully applied in various applications such as security surveillance, vehicle detection, and object detection in computer vision [6]. The use of the YOLO method in buoy detection for unmanned fast boats has several fundamental reasons. Firstly, YOLO's speed in object detection is crucial in the context of unmanned fast boats, requiring quick responses and minimal computational time. By using YOLO, buoy detection can be performed in real-time, enabling the boat to respond rapidly to changes in navigation conditions [7]. Thus, employing the YOLO method in buoy detection for unmanned fast boats provides advantages in speed, precision, and system integration required in dynamic and complex maritime navigation contexts [8].

2. Method

As for the tools employed in tracking detection using the YOLO method in the implementation of unmanned fast boats, these include, among others

A. Webcam

In this research, a Logitech C270 webcam is utilized to capture images or videos from the ship's surroundings [9]. The webcam will generate frames of images, which will then be processed using the YOLO method to detect buoy objects in real-time, with the webcam specifications listed in Table 1.

Table 1. Specification of Logitech C270 Webcam

Max Resolution	720p/30fps
Focus Type	Fixed Focus
Lens Technology	Standard
Cable Length	1.5 Meter
Compatible With	Windows 7, 8,10 Or later

B. Laptop

In this research, we utilize an ASUS VivoBook X421JQY_K413JQ laptop computer as the main processing device to run the YOLO model and analyze images or videos captured from the ship's surroundings[10], with detailed specifications provided in the table 2.

Table 2. Laptop Spesification

Type	Asus Vivobook X421JQY_K413JQ
Processor	I5-1035G1 Cpu @ 1.00Ghz (8 Cpus), ~1.2Ghz
Graphics	NVIDIA GeForce MX350
RAM	8GB DDR4
Resolusi Monitor	64 Fps
Harddisk	512GB SSD
Operating System	Windows 10 Home Single Language 64-bit

C. Buoy

In this study, red and green buoys are employed as objects to be detected and identified by the YOLO model[11], with the specifications available in Table

Table 3. Buoy Spesification

Tipe	Jenis	warna	Fungsi	Diameter
Lateral	Starboard Hand	Hijau	Menunjukkan posisi kanan saat kapal memasuki pelabuhan	400 mm
	Port Hand	Merah	Menunjukkan posisi kiri saat kapal memasuki pelabuhan	400 mm

D. CNN (*Convolutional Neural Network)*

CNN (Convolutional Neural Network) is an architecture specialized in processing image data. CNN consists of various layers, including convolutional layers responsible for performing convolution operations on input images to extract visual features[12]. This convolutional layer operates using filters that slide across the image, producing feature maps

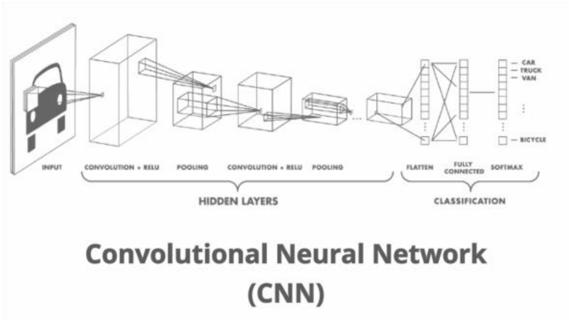


Figure 1. CNN (Convolutional Neural Network)

YOLO utilizes CNN as an integral part of its approach. CNN is employed for feature extraction from images used in object detection [13] . In YOLO, CNN helps transform the input image into increasingly abstract representations as the network depth increases. These representations are then used to predict bounding boxes and object class scores [14]. Overall, YOLO leverages the power of CNN in feature extraction and integrates it with real-time object detection methods to achieve fast and efficient object detection.

E. YOLO (You Only Look Once)

YOLO (You Only Look Once) is an object detection method designed to detect objects in real-time with a high speed[15]. The YOLO approach divides the image into a grid and utilizes Convolutional Neural Network (CNN) for feature extraction and prediction. Each grid is responsible for detecting multiple objects by generating bounding boxes and class scores [16].

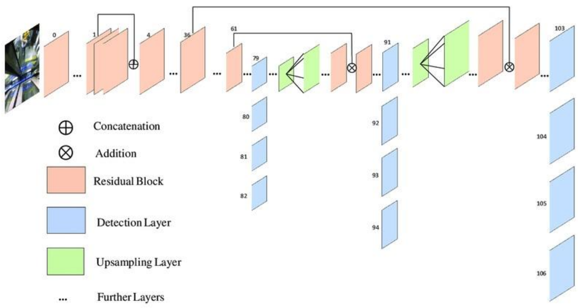


Figure 2. YOLO Architecture

In this study, the testing of red and green buoy object detection will be conducted through several crucial steps [17]. Firstly, the collection of research materials will be undertaken, including image data involving two buoy objects, namely red and green, for the processes of analysis, processing, and color detection testing. Subsequently, the collection of image dataset process will be carried out for analysis, processing, and color detection testing with a focus on these two buoy objects [18] . The third step involves the dataset labeling process to classify between red and green buoys, enabling precise model training. The labeled dataset training process is conducted using Google Collab, a cloud-based computing platform [19] . Following that, the data acquired from Google Collab will be trained into the YOLO v4 model as input, allowing the YOLO v4 model to recognize and detect objects in images or videos. The final step involves testing the accuracy of the trained YOLO model, assessing the model's ability to detect buoys with high precision. Thus, this system enables users to obtain real-time information about detected objects through a webcam display, presented with bounding boxes around these objects[20].

3. Result and Discussion

The detection of red and green buoys using the YOLO model with the CNN method involves a series of steps. These include inserting input images into the YOLO model, analyzing the images to generate bounding boxes and object labels, and conducting specific tests to filter detection results, focusing only on red and green buoys. By employing the CNN method, the YOLO model can learn distinctive visual features of red and green buoys, enabling accurate identification and differentiation of these objects. The detection results in the form of bounding boxes and labels are utilized for various purposes, such as navigation, monitoring, or further analysis in image processing, as illustrated in Figure 3.

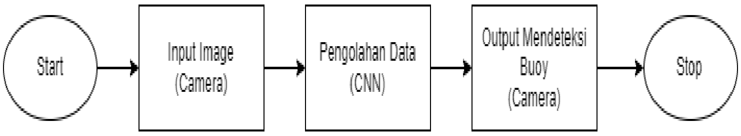


Figure 3. Diagram Block of System

In this discussion, we commence by elucidating a system diagram related to the path detection of red and green buoys, as depicted in the diagram shown in figure 4.

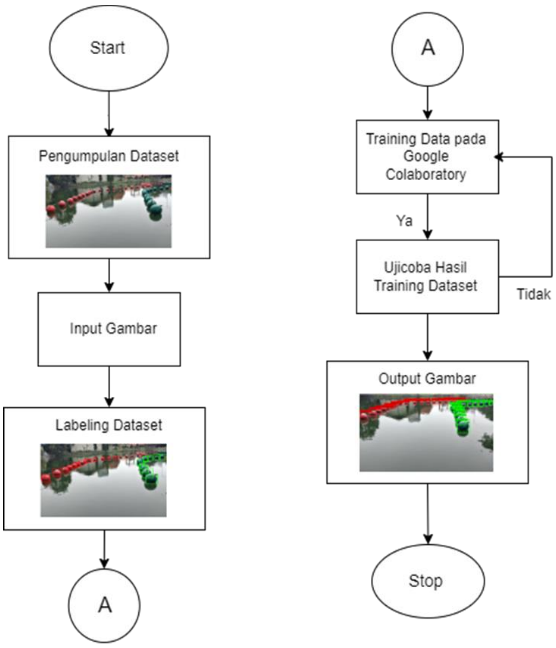


Figure 4. Flowchart of System

This system diagram illustrates the steps involved in the detection process of red and green buoy objects using the Logitech C270 webcam as the data acquisition tool. The process begins with the dataset collection phase, where images of red and green buoys are captured using the webcam as input. Subsequently, this dataset is labeled with appropriate annotations to distinguish between red and green buoys. The labeling process is carried out using the ASUS Vivo Book X421JQY_K413JQ laptop. Next, the labeled dataset is used to train the model using the Convolutional Neural Network (CNN) method through the Google Collaboratory platform. The training process aims to enable the model to learn the distinctive visual patterns of red and green buoys for accurate detection.

After the training process is completed, an experiment is conducted using the trained buoy dataset. In this experiment, a camera is employed to detect red and green buoys in images. The detection results are then displayed in the form of images showing the red and green buoys successfully identified by the model. This system diagram reflects a structured workflow, starting from dataset collection using a webcam to the output of images showcasing detected red and green buoys. By employing the CNN method and Google Collab, this system allows for accurate detection of red and green buoys and can be utilized in various applications requiring object identification. In this process, several images of red and green buoys are gathered to create the dataset, as depicted in figure 5.

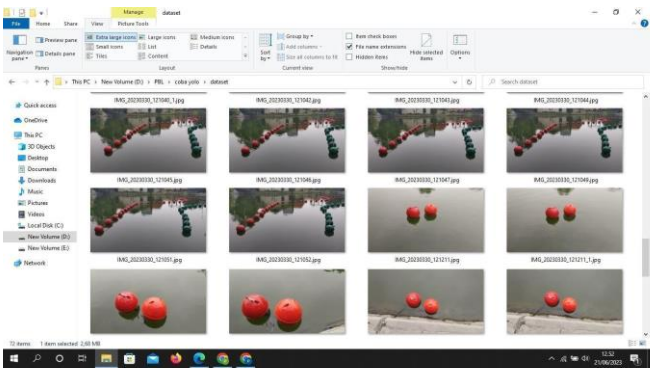


Figure 5. Dataset

After dataset acquisition, in the object detection of buoys using YOLO, CNN is utilized to analyze images and recognize red and green buoys. Initially, CNN undergoes training with a dataset containing annotated images of red and green buoys. This training process enables CNN to learn and identify patterns present in buoy objects. In the labeling process, we utilize the YOLO v4 application, which subsequently processes detection images according to the color of the objects. The following depicts an image of the object labeling process using the YOLO v4 application, as shown in the figure.

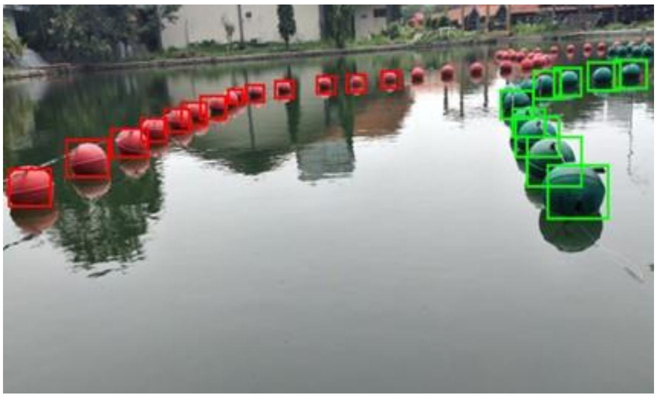


Figure 6. Labelling Dataset

After undergoing the training phase, the trained CNN model is utilized in the object detection process on new images. The images are divided into several grids, with each grid potentially having multiple bounding boxes containing objects. CNN predicts each bounding box, providing probabilities for the presence of an object and classifying whether it is a red or green buoy. After the labeling process, a pixel matrix will emerge for each image in the dataset, as depicted in Figure 7.

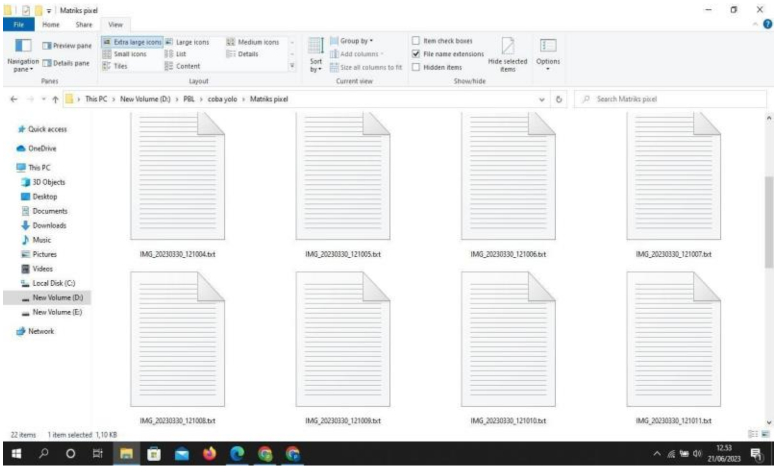
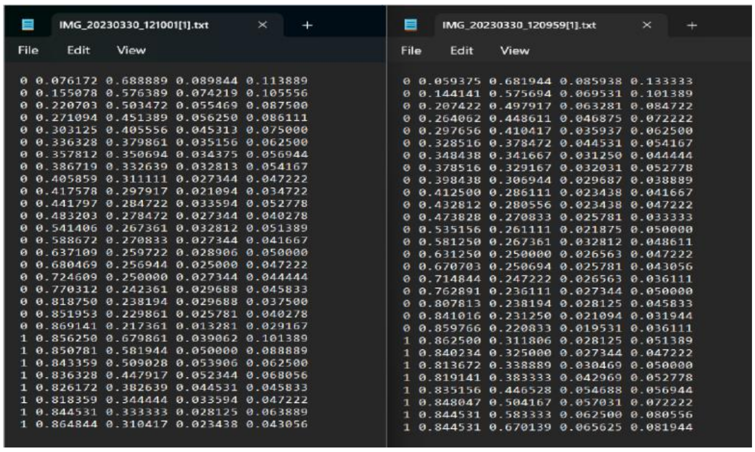


Figure 7. Result of Labelling

After the images in the dataset generate pixel matrices in the ".txt" format, each image will produce diverse output data based on the position or distance of the object from the webcam. The following is a comparison between two output images from each image in the dataset, as illustrated in Figure



```
IMG_20230330_121001[1].txt
File Edit View

0 0.076172 0.688889 0.089844 0.113889
0 0.155078 0.576389 0.074219 0.105556
0 0.220703 0.503472 0.055469 0.087500
0 0.271094 0.451389 0.056250 0.086111
0 0.303125 0.405556 0.045313 0.075000
0 0.336328 0.379861 0.035156 0.062500
0 0.357812 0.350694 0.034375 0.056944
0 0.386719 0.332639 0.032813 0.054167
0 0.405859 0.311111 0.027344 0.047222
0 0.417578 0.297917 0.021094 0.034722
0 0.441797 0.284722 0.033594 0.052778
0 0.483203 0.278472 0.027344 0.040278
0 0.541406 0.267361 0.032812 0.051389
0 0.588672 0.270833 0.027344 0.041667
0 0.637109 0.259722 0.028906 0.050000
0 0.680469 0.256944 0.025000 0.047222
0 0.724609 0.250000 0.027344 0.044444
0 0.770312 0.242361 0.029688 0.045833
0 0.818750 0.238194 0.029688 0.037500
0 0.851953 0.229861 0.025781 0.040278
0 0.869141 0.217361 0.013281 0.029167
1 0.856250 0.679861 0.039062 0.101389
1 0.850781 0.581944 0.050000 0.088889
1 0.843359 0.509028 0.053906 0.062500
1 0.836328 0.447917 0.052344 0.068056
1 0.826172 0.382639 0.044531 0.045833
1 0.818359 0.344444 0.033594 0.047222
1 0.844531 0.333333 0.028125 0.063889
1 0.864844 0.310417 0.023438 0.043056
```

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IMG_20230330_120959[1].txt
File Edit View

0 0.059375 0.681944 0.085938 0.133333
0 0.144141 0.575694 0.069531 0.101389
0 0.207422 0.497917 0.063281 0.084722
0 0.264062 0.448611 0.046875 0.072222
0 0.297656 0.410417 0.035937 0.062500
0 0.328516 0.378472 0.044531 0.054167
0 0.348438 0.341667 0.031250 0.044444
0 0.378516 0.329167 0.032031 0.052778
0 0.398438 0.306944 0.029687 0.038889
0 0.412500 0.286111 0.023438 0.041667
0 0.432812 0.280556 0.023438 0.047222
0 0.473828 0.270833 0.025781 0.033333
0 0.535156 0.261111 0.021875 0.050000
0 0.581250 0.267361 0.032812 0.048611
0 0.631250 0.250000 0.026563 0.047222
0 0.670703 0.250694 0.025781 0.043056
0 0.714844 0.247222 0.026563 0.036111
0 0.762891 0.236111 0.027344 0.050000
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0 0.841016 0.231250 0.021094 0.031944
0 0.859766 0.220833 0.019531 0.036111
1 0.862500 0.311806 0.028125 0.051389
1 0.840234 0.325000 0.027344 0.047222
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1 0.835156 0.446528 0.054688 0.056944
1 0.848047 0.504167 0.057031 0.072222
1 0.844531 0.583333 0.062500 0.080556
1 0.844531 0.670139 0.065625 0.081944
```

Figure 8. The result of the pixel matrix comparison

In this experiment, ten images from the dataset were tested ten times. The objective is to allow the model to learn patterns and features present in the objects within the images. The results of the red and green buoy detection tests can be observed in the table.

Table 4. Experiment Results

Gambar	Total Buoy		Persen Deteksi (%)
	Asli	Terdeteksi	
	4	4	100
	12	11	92
	21	19	90
	69	31	45
	60	24	40
	60	20	34
	60	22	37

Gambar	Total Buoy		Persen Deteksi (%)
	Asli	Terdeteksi	
	60	20	34
	60	18	30
	60	24	40

Based on the information in Table 3.1, there is variation in the system's accuracy in identifying red and green buoys. Some results show a perfect accuracy level of 100%. This phenomenon occurs when the webcam is close to the buoy, producing high-quality images where the buoy objects are clearly visible. This enables object detection methods like YOLO to analyze images more effectively and provide more accurate results. On the other hand, when the distance between the webcam and the buoy is too far, the detection performance using the webcam on buoys decreases. For example, out of ten images taken with a significant distance between the webcam and the buoy, some results show less perfect accuracy, such as 92%, 90%, 45%, 40%, 34%, 37%, 34%, 30%, 40%. With an average detection result of 41.42%, only about 41.42% of the images are accurately detected by the YOLO method. This percentage indicates that when the webcam is too far from the buoy, the ability of the YOLO method to detect buoy objects becomes less accurate. From the training process with 466 buoys, only 193 buoys were successfully detected by the applied method, with an average accuracy of 41.42%. Although the accuracy level needs improvement, especially for buoys positioned far from the camera, there is still potential for enhancement by refining the method or expanding the training dataset. These results provide an overview of how well the system can recognize and detect objects with an acceptable success rate, but there is room for improvement and further performance enhancement. From the results of the sample image tests, the following calculations can be obtained:

$$\text{Acuration} = \frac{numberofbuoysdetected}{totalbuoys} x100\%$$

$$= \frac{193}{466} x100\%$$

$$= 41{,}42\%$$

4. Conclusion

From the experiments conducted, several conclusions can be drawn, including:

1. When red and green buoys are placed near the webcam, some results show a perfect accuracy of 100%. This is because when the webcam is near the buoy, the generated images have good quality, and the buoy objects can be seen clearly. This allows object detection methods, such as YOLO, to analyse images more effectively and produce more accurate results. Methods like YOLO can recognize and detect buoys with very high accuracy when they are close. However, when the webcam and buoys are too far apart, the detection performance using the webcam on buoys will decrease. Out of a total of 10 images taken at a distance, there were some accuracy results that were less than perfect, with percentages ranging from 92%, 90%, 45%, 40%, 37%, 34%, to 30%.
2. From the training process involving 466 buoys, 193 buoys were detected using the applied method, resulting in an average accuracy of 41.42%. Although this accuracy level is not optimal due to the many buoys positioned far from the camera, there is still potential to improve it by refining the method used or expanding the training dataset.

Acknowledgment

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