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Deep Learning Yolo-Based Health and Safety Equipment Detector Prototype

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Abstract— *Occupational health and safety is the most vital issue for achieving goals in a project in the construction field. Technology and information in image processing can be a solution to increase efficiency and speed in monitoring employee K3 equipment. In this research, the research approach used is a quantitative research approach. At this stage, several observations are made first to find out what stages need to be done before carrying out research and determine the formulation of problems that will be raised in the research. Offline testing is done by giving input to YOLO using videos that have been taken previously. Online or Real Time testing is done by detecting directly using a camera connected to a laptop, the function of this test is to determine the performance of the system when applied directly.*

Keywords— *Occupational Health and Safety, Deep Learning, YOLO*.

I. INTRODUCTION

Occupational health and safety is the most vital issue for the achievement of goals in a project in the construction field. According to the International Labor Organization (ILO), every year there are more than 250 million work accidents and more than 160 million workers suffer from illness due to accidents at work. At least more than 1.2 million workers lose their lives due to work-related accidents and health [1]. The high number of work accidents is allegedly sourced from the lack of awareness of workers in complying with work safety regulations, as stipulated in the Minister of Manpower and Transmigration Regulation No.Per.08/Men/VII/2010 concerning Personal Protective Equipment (PPE) [2].

Technology and information in image processing can be a solution to improve efficiency and speed in monitoring employee OHS equipment. OHS equipment monitoring system using artificial intelligence cannot be separated from the detection process. This is because monitoring K3 equipment is an action taken after the device detects K3 equipment used by workers. The detection process serves as input conditions that will be processed and processed into decisions by the device. The detection of OHS devices is carried out with the help of cameras installed in workshops that require the use of safety equipment, especially Subscribe to DeepL Pro to edit this document. Visit www.DeepL.com/pro for more information Safety vests and helmets [3]. There are many methods that can be used for object detection, one of which is the YOLO (You Only Look Once) detection method [4].

The YOLO algorithm offers a number of significant advantages in the field of object detection, especially in terms of processing speed and high accuracy rates when compared to other conventional methods. The ease of use and training of the YOLO model makes it an attractive option for novice researchers. YOLO's ability to process up to 45 frames per second, even reaching 155 frames per second with the fast YOLO version, demonstrates its outstanding efficiency. The versatility of YOLO has been proven through its application to various object detection and recognition projects, as seen in the study titled Implementation of the Yolov8 Method to Detect Work Safety mAP50 reached 99.5%. While the test results with 100 images, the accuracy reached 99% [5]. In another study with the title Personal Protective Equipment (PPE) Detection System for Construction Workers Based on Convolutional Neural Network using a camera and object detection algorithm YOLOv7 based on Convolutional Neural Network which achieved good accuracy at an ideal distance of 3 meters and 4.5 meters with mAP values of 0.912 and 0.947 respectively. Testing the alarm mechanism shows an accuracy of 1.0 at a distance of 1.5 meters and 3 meters [6]. In a similar study with the title Implementation of the YOLO Method on Detection of Complete Safety Clothing in Construction Projects The decision- making system uses the YOLOv5 method. 140 image data consisting of 96 train set data, 28 valid sets and 16 test sets and successfully detect well and correctly images using safety clothing and images not using safety clothing with 83% accuracy.

The problem formulations in this study are: (1) how to design a detector system for Occupational Health and Safety (K3) equipment based on deep learning YOLO, (2) how the effect of object distance on the accuracy of the Occupational Health and Safety (K3) equipment detector system based on deep learning YOLO.

The objectives of this research are as follows: (1) Knowing the design of the YOLO deep learning-based occupational health and safety (K3) equipment detector system and (2) Knowing the effect of object distance on the accuracy of the YOLO deep learning-based occupational health and safety (K3) equipment detector system.

II. THEORETICAL REVIEW

A. *Occupational Health and Safety (OHS)*

Occupational Health and Safety Management System is an international standard that provides guidelines for the implementation of an Occupational Health and Safety Management System (OHS), equipped with instructions for use so that companies can improve occupational safety and health carried out in the company. environment proactively in preventing work accidents and the negative impact of activities on workers' health, including the occurrence of occupational diseases (PAK). The application of ISO 45001 is designed to be easy to implement in any company, regardless of size or type. The content of this standard is a guideline for SMK3. In addition, ISO 45001:2018 enables organizations to proactively improve SMK3 performance in preventing injuries and illnesses. Please note, the government requires an organization or business to implement SMK3. According to Purwanto et al., (2020) ISO 45001 is an international standard that sets standards or requirements for occupational health and safety / (SMK3) K3 Management Systems, with instructions for use, enabling organizations to proactively improve SMK3 performance in terms of preventing accidents, illnesses and occupational diseases [7].

Occupational Health and Safety (OHS) is an aspect of labor protection that also functions to protect company assets with the main objective of guaranteeing safe and healthy working conditions for every employee and protecting Human Resources (HR). The purpose of OHS is to reduce the number of work accidents, especially in Indonesia. This can be achieved if the company always pays attention to occupational safety and health factors, because this attention will improve employee performance. Attention to workers' health initially emphasized more on occupational safety issues, namely protecting workers from losses or injuries caused by work accidents. Along with industrial development, companies began to pay attention to worker health in a broader sense, namely ensuring that workers are free from physical and psychological illnesses.

B. Deep Learning

By definition, deep learning is a part of machine learning that is used for modeling high-level abstractions on data based on algorithms using implementation layers and using complex structures or otherwise, consisting of several non-linear transformations [8].

Deep learning has a feature to extract patterns from data that help the model to distinguish classes so that this feature also plays a role in achieving good prediction results, this feature is called Feature Engineering. Deep learning is a branch of machine learning inspired by the human cortex by applying artificial neural networks that have many hidden layers [9].

C. YOLO

You Only Look Once (YOLO) is a real-time object detection algorithm that utilizes a single Convolutional Neural Network (CNN) [10]. In one evaluation, YOLO is able to predict the bounding box and object class probability simultaneously by considering all image features [11]. This approach enables efficient and accurate object detection. This neural network model utilizes all the information in the image to estimate the position and presence of the object within each bounding box. The prediction process for all bounding boxes and their probabilities is done simultaneously in one evaluation.

III. Research Methods

In this research, the research approach used is a quantitative research approach. At this stage, several observations are made first to find out what stages need to be done before carrying out research and determine the formulation of problems that will be raised in the research. Literature study is carried out to learn more about the research to be done so as to get maximum results and according to the desired target, then proceed to the design of the system in the form of electrical detection devices, taking data in the form of images and processing the data that has been obtained.

The data processing system developed in this research serves as a framework for processing the collected image datasets. The main objective of this system is to produce an artificial intelligence model that can be integrated with the YOLO algorithm to detect work safety equipment. The data processing process begins with the data acquisition stage, where images are collected either through direct image capture using a camera or through online sources (internet). The addition of data from the internet aims to enrich the variety of training data and improve the accuracy of the resulting model.

Before the You Only Look Once (YOLO) object detection model is trained, the image data to be used first undergoes a series of preprocessing processes. This preprocessing stage is divided into two, namely resizing and cropping the image, as well as annotating the objects contained in the image. The purpose of image resizing and cropping is to make all image data have uniform dimensions and conform to the input requirements of the YOLO model, which is 416 x 416 pixels. These dimension requirements have been defined in the official YOLO documentation. Furthermore, at the annotation stage, each object to be detected in the image is marked with a bounding box. This marking process is very important because it will be a reference for the YOLO model in learning the visual characteristics of various objects.

This research was conducted at PT Prima Barra Sejahtera which is located at Andalusia @Regency Giri Housing, Kebomas sub-district, Gresik district, East Java.

IV. Results and Discussion

Dataset Preparation is a crucial stage in deep learning model development that focuses on preparing the data before it is used in the training process. In this phase, the data to be used is collected, cleaned, and processed to ensure its quality. This process starts with data collection. Then, the data is annotated or labeled, so that the model can learn important patterns or features from the data. Next, the data is divided into subsets such as training, validation, and testing to ensure fair model evaluation and prevent overfitting. Data augmentation processes, such as rotation or rescaling are also applied to increase the variety and diversity of the data. By preparing the dataset thoroughly, machine learning models can be trained with high-quality data, which contributes to better model performance and accuracy.

The evaluation of the YOLOv8 model is conducted with the aim of selecting the most optimal model for the object detection task. This evaluation process involves using the

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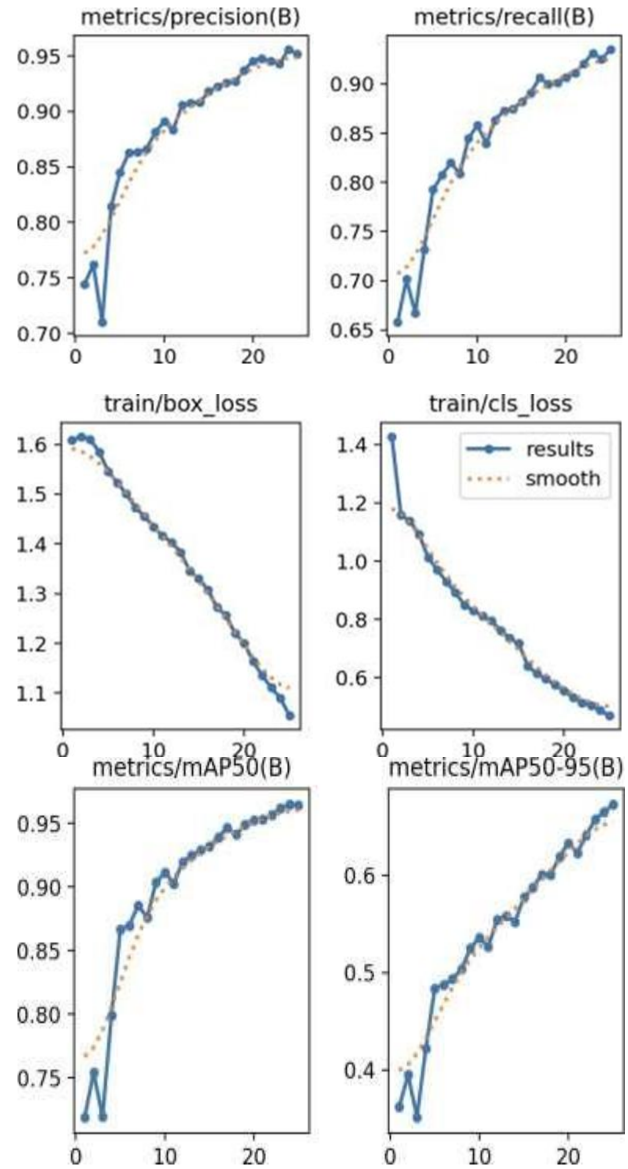
default hyperparameters that have been set in YOLOv8, namely the image size of 640 pixels, the number of epochs of 25, and the batch size of 16. The combination of these hyperparameters will be tested on various YOLOv8 model configurations. Based on the results of the YOLOv8 model training evaluation, the average precision value (mAP@0.95) is 0.67305 or equivalent to 67% training accuracy. A visualization of the training process is shown in Figure.



Unknown:
TP = 0.95
FP = 0.05
FN = 0.05
TN = 0.95
The calculation of the precision value is as follows:

$$Precision = \frac{TP}{TP + FP}$$

$$Precision = \frac{0,95}{0,95 + 0,05}$$

Precision = 0.95 or 95%

The calculation of the recall value is as follows:

$$Precision = \frac{TP}{TP + FP}$$

$$Precision = \frac{0,95}{0,95 + 0,05}$$

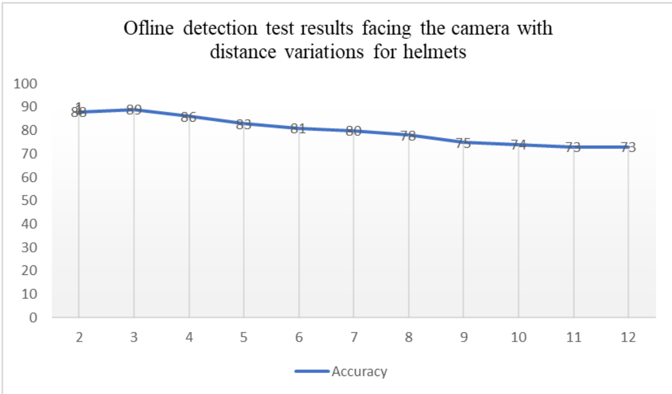
Recall = 0,95 or 95%
Calculation of accuracy value as follows:

$$\text{Akurasi} = \frac{TP + TN}{TP + TN + FN + FP}$$

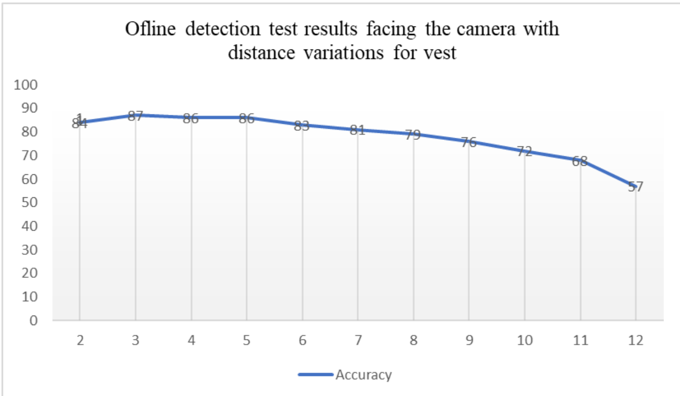
$$\text{Akurasi} = \frac{0,95 + 0,95}{0,95 + 0,95 + 0,05 + 0,05}$$

Accuracy = 0.95 or 95%

This test was conducted with the subject wearing a helmet and facing directly at the camera, where the distance between the subject and the camera was varied to measure the detection accuracy. The test results with distance variations are presented in detail in Figure.



This test was conducted with the subject wearing a vest and facing directly at the camera, where the distance between the subject and the camera was varied to measure the detection accuracy. The test results with distance variations are presented in detail in Figure.



Offline detection testing was conducted to evaluate the accuracy of the system in recognizing helmets at various dynamic positions and distance variations. This testing process involves dynamic movement of objects to simulate real conditions in the field. The test results with distance variations are presented in detail in Figure.

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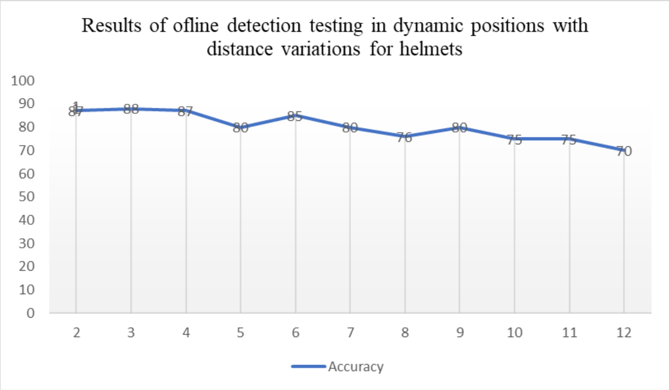

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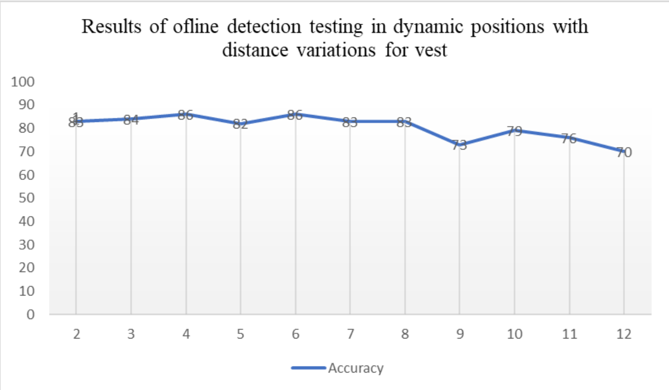
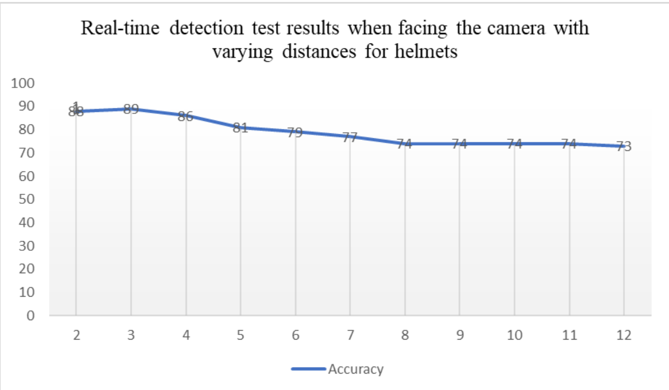
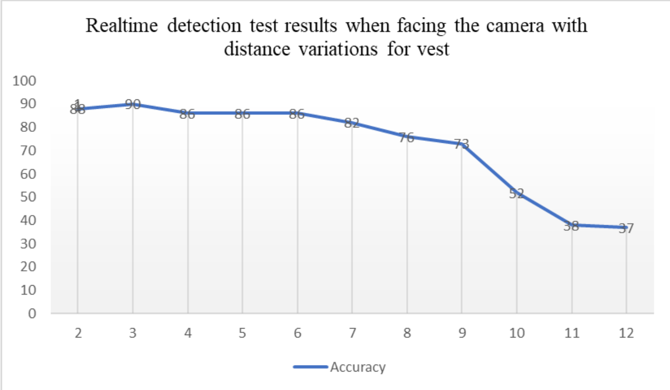


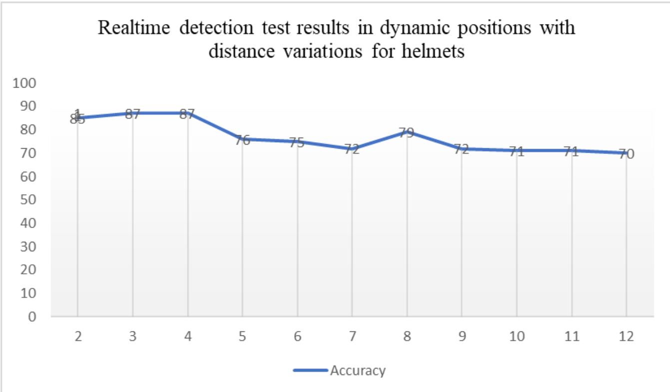
The test was conducted by detecting the use of a helmet in real-time on a subject facing directly at the camera with various distance variations. The purpose of this test is to evaluate the performance of the detection system in identifying helmets at different distances. The test results with various distance variations are presented in Figure.



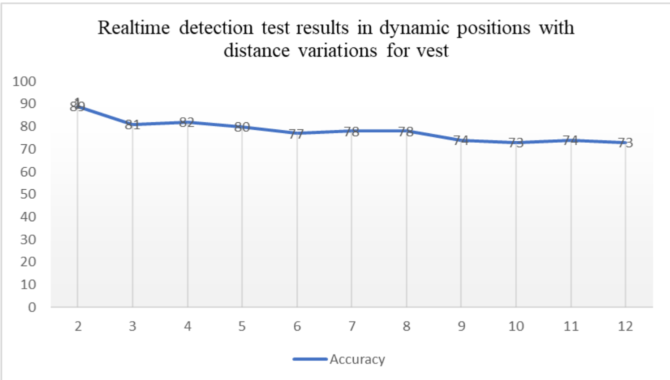
Real-time vest detection testing was conducted with various distance variations to test the accuracy of the system in detecting objects when the subject is facing the camera. The purpose of this test is to evaluate the performance of the detection system in identifying helmets at different distances. The test results with various distance variations are presented in Figure.



Real-time detection testing in dynamic positions was conducted by varying the distance between the camera and the subject wearing a helmet. The distance used in this test ranges from 2 to 12 meters to evaluate the accuracy of the system in real conditions. The test results with various distance variations are presented in Figure.



Real-time detection testing in dynamic positions was conducted by varying the distance between the camera and the subject wearing the vest. The distance used in this test ranges from 2 to 12 meters to evaluate the accuracy of the system in real conditions. The test results with various distance variations are presented in Figure.



V. Conclusion

The YOLO deep learning-based occupational health and safety (OHS) equipment detector system has been designed and functions well in detecting workers who do not use personal protective equipment (PPE). The system can detect violations of employees who do not use helmets and vests and produce evidence in the form of screenshots.

The YOLO deep learning-based occupational health and safety (OHS) equipment detector system with distance variables shows a significant effect, where an increase in distance causes a decrease in accuracy. This is due to the smaller size of the detected object, so that the system has difficulty in recognizing the object. In this study, the optimal distance detected is 3.

VI. Limitation

In conducting this research, the obstacles faced were the lack of light at the location so that the camera could not record optimally. The specifications of the camera and laptop also affect the results and speed of YOLO work. This study used YOLOv8 and focused on testing the position facing the camera and dynamic position in the workshop.

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