Application Of Yolo V8 For Product Defect Detection In Manufacturing Companies

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ABSTRACT

One important aspect in the production process is maintaining product quality and avoiding defects that could harm the company. This research aims to improve quality and avoid product defects that are detrimental to the company, especially defects in the form of bubbles in the product, by using YOLOv8. The dataset consists of 100 data which is divided into 80 for training and 20 testing data with an epoch value of 100. To obtain optimal bubble detection results, this research chose the latest version of YOLOv8 and compared several models, namely YOLOv8n, YOLOv8s, YOLOv8m, YOLOv8l, and YOLOv8x. The research results show that YOLOv8m achieves the highest accuracy among other models with a mAP value of 0.712, precision of 0.764, recall of 0.659, and F1-score of 0.708. This research highlights the potential of detection models that can detect bubbles precisely and accurately.

Keywords: Product Defects, Bubble Detection, Manufacturing Companies, YOLOv8 Models

INTRODUCTION

Industrial development occurs rapidly, so companies must continuously produce high quality products that meet expectations. Manufacturing companies face major challenges regarding operational efficiency and resource management(Arther Sandag et al., nd). High quality products at competitive prices will attract the attention of consumers and have competitiveness in the manufacturing industry market. The manufacturing industry itself is a sector that converts raw materials, components or other materials into finished goods that have added value, either mechanically using machines or manually without machines.(Setia Pratama, nd). Quality control does not occur haphazardly, but rather through serious efforts to achieve it. Optimal quality control can have a big impact on a company's production results. One important aspect in the production process is maintaining product quality and avoiding defects that could harm the company(Aisya Putri Zanuarizqi, 2021). Product defects can come from various sources, such as manufacturing defects, equipment failure, or failure of existing quality control systems.

Even though the production process has been carried out optimally, sometimes errors still occur that are below the tolerance limits set by the company, so that the production results are considered defective products.

Therefore, if this product can be detected early, the negative impact on the company and the reduction in rejected goods may be immediately prevented. The use of the CNN algorithm with the YOLOv8 architecture has the ability to detect and identify defects in products in the form of bubbles which are often missed when checking manually.

Several previous studies have discussed CNN and also YOLOv8. Research conducted by Nurhaliza Juliyani Hayati, Dayan Singasatia, and Muhamad Rafi Muttaqin shows that using the You Only Look Once (YOLO) v8 algorithm can detect the type and count the number of vehicles to overcome various existing problems. The methodology applied follows the AI project cycle which includes the stages of problem scoping, data acquisition, data exploration, modeling, and evaluation using a confusion matrix. The results of the confusion matrix evaluation show an accuracy level of 89%, precision 89%, recall 90%, and a weighted comparison of precision and recall produces an F1-Score value of 89%.(Hayati et al., 2023).

In research conducted by Muhammad Nur Ihsan Muhlashin and Arnisa Stefanie, an eye disease classification system was proposed that can detect eye diseases automatically using YOLO V8. This system aims to detect eye disease early in order to prevent further, more serious development. The test results of the developed model show an accuracy value of 92%, precision of 91%, recall of 92%, and F1-score of 91%(Nur et al., 2023).

In research conducted by Aris Setiyadi, Ema Utami, and Dhani Ariatmanto, the method used was to modify the YOLOv8 architecture in the head section to detect human objects in grayscale images. The training process was carried out four times using the default architecture, as well as three modified architectures, namely Model 1, Model 2, and Model 3. The results show that the default model achieved an mAP value of 76, Model 1 achieved an mAP value of 66, Model 2 achieved an mAP value of 81, and Model 3 produces a mAP value of 80. This research shows that modifying the YOLOv8 architecture in the head section can influence training results and produce a better model compared to the default architecture which only achieves a mAP value of 76. The best results were obtained on Model 2 with a 40x40x512xW layer configuration, resulting in a model with a mAP value of 81(Aris Setiyadi et al., 2023).

It can be explained in related research that has been carried out in previous research, the use of defect detection technology is crucial to support manufacturing companies' efforts to maintain the quality of their products. Using Yolo v8 has proven effective in many image processing applications, including object detection and visual analysis. Therefore, implementing Yolo v8 for product defect detection in manufacturing companies is a solution to optimize the overall production process, identify defects quickly, and reduce losses (defect costs) due to defective products (Huang et al., 2023).

METHODS

Research Procedures

It can be seen in the research procedure in Figure 1, the initial stage of the research is collecting datasets for training the detection model required in this research. The detection model obtained from this training is to train the model to recognize products that are okay and those that are rejected.

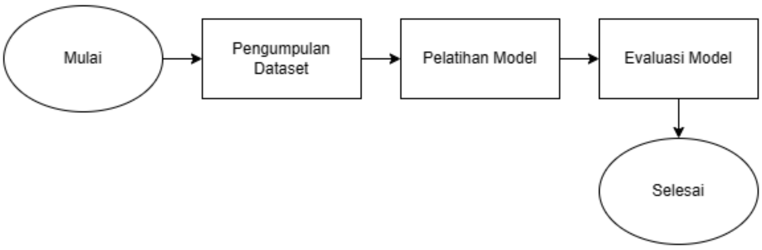

Figure 1. Research Procedures

Dataset Collection

This step involves an image processing process that involves collecting images of company product objects as data preparation. This training dataset comes from an industrial camera at a manufacturing company, consisting of 100 product images with an initial size of 1200x640 which are then divided into 80 training images and 20 validation image data. An example of an image dataset can be seen in Figure 2. Next, the image data collection is stored in an organized folder.

Figure 2. Product Dataset

Model Training Process

In this stage of the process, the dataset is trained using YOLOv8 by changing the dataset size to 640x640, to lighten and speed up the training process, with 100 epochs. The model training process is carried out using the Google Colab platform. The choice of Google Colab as a training platform was due to the availability of a 12 GB GPU from Nvidia, which allows data training to be carried out efficiently and quickly(Horvat et al., nd).

Model Evaluation

The accuracy evaluation step is the next phase, where the main goal is to evaluate the accuracy value of the previously trained model. The assessment of the accuracy of the YOLOv8 model is measured through the confusion matrix resulting from the testing process(Kiki Wahyuddin et al., 2023). This step also plays a crucial role in object detection, because the stability of object detection requires a high level of accuracy. Therefore, evaluating the accuracy value in object detection is important so that the accuracy value remains stable in each image or video(Guo et al., 2022).

The model evaluation process includes precision, accuracy, recall and F1-Score values(Resti et al., nd).With the following formula:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

$$precision = \frac{TP}{TP+FP} \quad (2)$$

$$recalls = \frac{TP}{\text{TP+FN}} \quad (3)$$

Information:

- TP (True Positive): The number of cases in which the model successfully predicted a positive result correctly.
- TN (True Negative): The number of cases in which the model successfully predicted a negative outcome correctly.
- FP (False Positive): The number of cases where the model incorrectly predicted a negative result as positive.
- FN (False Negative): The number of cases where the model incorrectly predicted a positive result as negative.

$$F1=\frac{2\times \text{precision}\times \text{recall}}{\text{precision}+\text{recall}} \quad (4)$$

Information:

- *F1-Score*is the harmonic average of precision and recall. F1 score is used as a measure of balance between precision and recall, especially when there is an imbalance between the number of positive and negative classes(Yoga Wibowo et al., 2023).

You Only Look Once (YOLO) v8

The latest version of the real-time object detection algorithm, "You Only Look Once" (YOLO) v8, offers significant improvements in accuracy, speed and computational efficiency. Updates to the network architecture and training algorithms enable YOLO v8 to better detect various types of objects, including small and partially occluded objects.(Maulana et al., 2024).the latest version of YOLOv8 and compare several models, namely YOLOv8n, YOLOv8s, YOLOv8m, YOLOv8l, and YOLOv8x. This model is lighter and can be operated on devices with limited resources, such as mobile devices and edge devices. Other advantages include the ability to process images and videos faster, support for various types of objects(Jayidan et al., 2024).

RESULTS

This training program is based on Python-3.11.4 (based on pytorch-2.0.1). The simulation tool used in this experiment is Google Colab. The YOLO models trained are YOLOv8n, YOLOv8s, YOLOv8m, YOLOv8l, and YOLOv8x and are carried out by testing the data that has been collected to determine the best model by considering the test results based on the evaluation matrix.

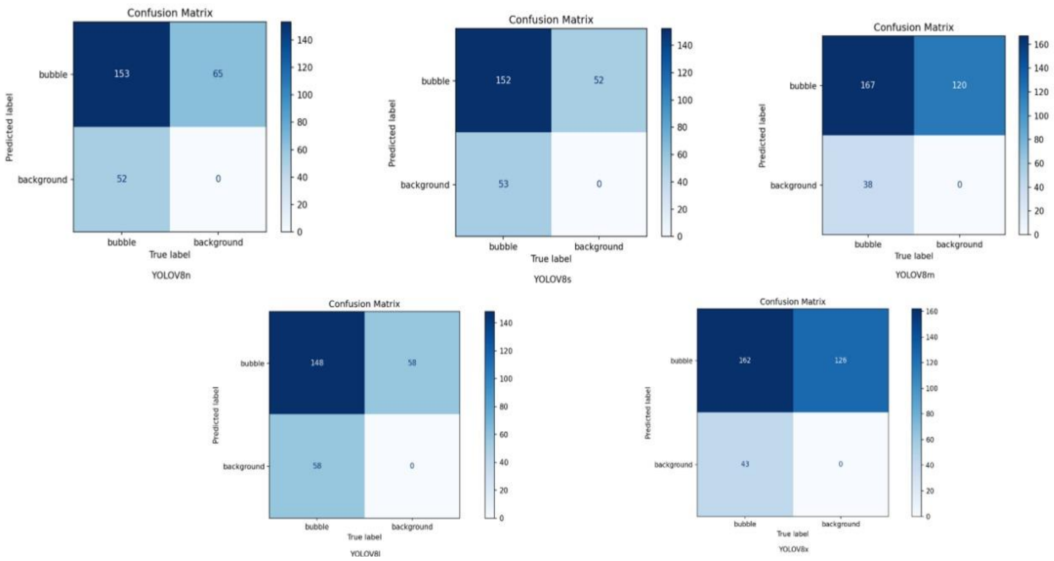

Figure 6. Training Dataset Results

It can be seen in Figure 6, a comparison of the results of the confusion matrix training dataset between several Yolo v8 models created to detect bubbles in products. In this comparison, it is clear that the total of each Yolo v8 confusion matrix model exceeds the initial 100 datasets, indicating that there were likely multiple experiments or cross-validations performed, rather than just one test data set. Therefore, each confusion matrix shows the results of several possibly different subsets of data.

It can be seen that the YOLOv8m model has the highest True Positive value, namely 162, which means that the model is most accurate in identifying bubbles that actually exist, correctly classifying them as bubbles. However, this model only recorded a True Negative value of 38, indicating that this model often failed to detect bubbles. From these results in this study using Yolo v8 with the YOLOv8m model in detecting objects.

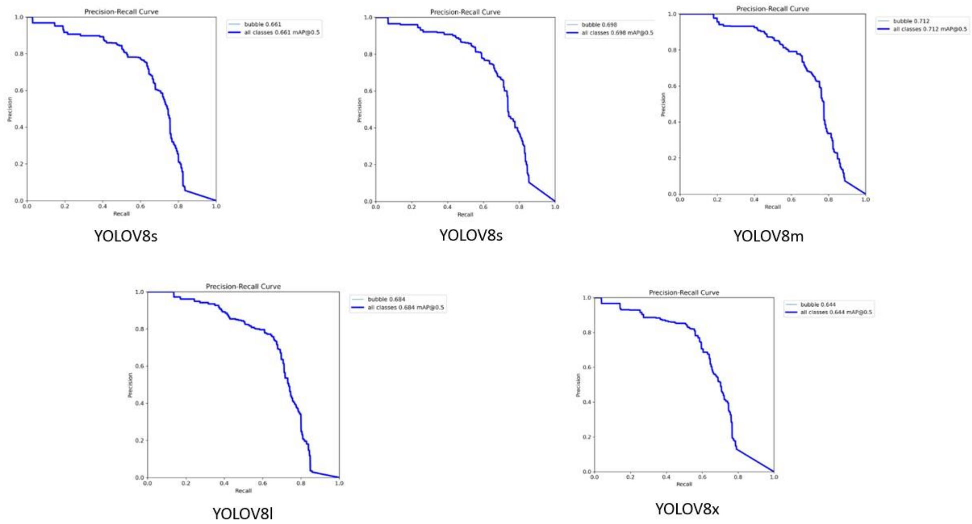

Figure 7. Precision and Recall Curves

Precision and recall curves are used to evaluate model performance objectively, with precision on the vertical axis and recall on the horizontal axis. In this study, IoU 0.5 or mAP50 was used as the threshold for detecting bubbles. The higher the AUC on the precision and recall curve, the better the model's ability to differentiate between positive and negative classes. The closer the curve value is to 1.00, the better the model performance. In this study, the AUC precision and recall curve that is closest to 1 and the largest among the other models is the YOLOv8m model with a value of 0.712, as shown in Figure 7.

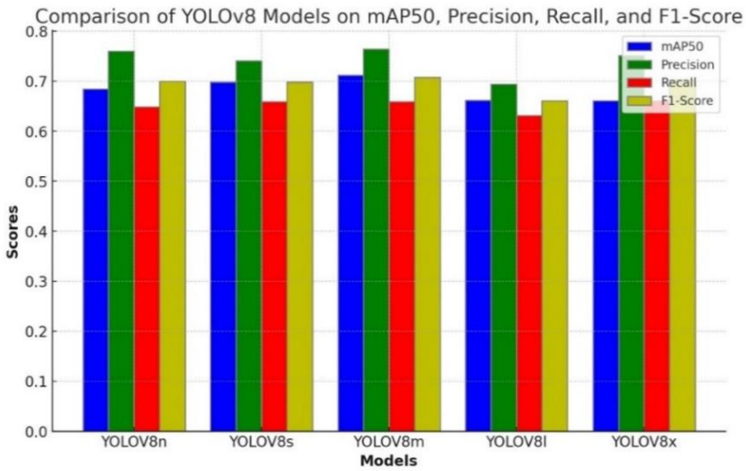

Figure 8.*Comparison of the YOLOv8 models on the bubble dataset*

It can be seen in Figure 8. To obtain optimal bubble detection results, this research chose the latest version of YOLOv8 and compared several models, namely YOLOv8n, YOLOv8s, YOLOv8m, YOLOv8l, and YOLOv8x. All experiments were conducted using the same tools, datasets, and proportions of training and testing sets. Comparison data between the models, including mAP, precision, recall, and evaluation using F1-score, mAP50 (Mean Average Precision at 50%) or IoU (Intersection over Union) are the metrics used to evaluate the performance of object detection models.

Table 1. Best Results from YOLO v8

Model	mAP50	Precision	Recall	F1-Score
YOLOV8n	0.684	0.76	0.649	0.700
YOLOV8s	0.698	0.741	0.659	0.698
YOLOV8m	0.712	0.764	0.659	0.708
YOLOV8l	0.662	0.694	0.631	0.661
YOLOV8x	0.661	0.751	0.661	0.703

In table 1, it can be seen that the model with the highest mAP is YOLOv8m with a value of 0.712, followed by YOLOv8s (0.698), YOLOv8n (0.684), YOLOv8l (0.662), and YOLOv8x (0.661). Apart from that, YOLOv8m also shows the highest precision, recall and F1-score values, which indicate excellent model evaluation accuracy. The YOLOv8m model is also able to increase accuracy in detecting bubbles.

This is in line with research by Julian et al. which shows that YOLOv8m is a better model to achieve high precision (Julian et al., 2024). In this study, we required high precision to obtain precise bubble measurements.

Figure 10. Bubble Detection Results

As can be seen in Figure 10, the overall evaluation value shows that the product detection system analysis by identifying bubbles in products using YOLOv8 provides good performance. The weakness of YOLOv8m during its development was the low recall value, but the results of this study show different results from other studies. Apart from that, the accuracy value has not reached 0.712 due to a lack of precision when processing the bounding box with surrounding objects, as well as a lack of the required dataset.

CONCLUSION

Based on the research and testing that has been carried out, it was found that the YOLOv8m model is the model with the best performance. This was obtained based on the AUC of the precision and recall curve which is closest to 1.00, namely 0.712, as well as evaluation results with an mAP value of 0.712, precision of 0.764, recall of 0.659 and F1-score value of 0.708. This shows that the results of the product detection in the form of bubbles in the product were successful and obtained unsatisfactory evaluation and test results due tolack of precision when processing bounding box objects with surrounding objects and also a lack of required datasets.

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