Misaligned Bolt Detection and Classification using YOLOv8

George Albert Bitwire
Graduate School of Electronic and Electrical Engineering, Kyungpook National University
Daegu, Republic of Korea
bitwire@knu.ac.kr

Steve Kuh
CEO
Bonafi, Inc
Los Angeles, CA, USA
steve@bonafi.io

Dong Seog Han*
Graduate School of Electronic and Electrical Engineering, Kyungpook National University
Daegu, Republic of Korea
dshanemailknu.ac.kr

***Abstract*—Bolts play a crucial role as structural components in buildings, machinery, transport systems, power plants, and aircraft. Any instance of a misaligned bolt can result in system failures. To identify misaligned bolts, machine learning techniques have been integrated into structural monitoring. Consequently, this paper presents a YOLOv8-based tool for detecting misaligned bolts. We employed image datasets containing valves to train YOLOv8, comprising 43 images, each containing at least two bolts. To optimize the dataset for deep learning and mitigate overfitting, we utilized data augmentation techniques, including flipping, rotation, shifting, zooming, as well as adjusting contrast, hue, and saturation. We used the confusion matrix and accuracy metrics to evaluate our model's performance. From our experiments, YOLOv8 demonstrated the ability to detect the various classes of bolts with an average accuracy of 90%.**

***Index Terms*—Misaligned Bolt, YOLOv8, Deep Learning, Object Detection**

I. Introduction

Misaligned bolts in vital structural elements such as buildings, machinery, transportation networks, fuel pipelines, power generation facilities, and aircraft have the potential to trigger system failures [1]. Such failures not only result to loss of properties but can also lead to fatalities. Misaligned bolts in machinery can result in malfunctions or breakdowns, consequently causing production disruptions, downtime, and the potential for damage to other equipment and products [2]. Misaligned bolts in aircraft components can pose a serious risk, potentially leading to accidents and endangering the lives of passengers and crew, as well as resulting in substantial financial losses for the airline. Hence, early detection of misaligned bolts across different structural components can avert such catastrophes. The aim of this project is to utilize computer vision and deep learning methodologies to identify misaligned bolts in valves prior to their deployment.

II. Method

In this section, we delve into the application of YOLOv8 on the dataset, detailing the step-by-step process, which includes data collection, data annotation, data augmentation, data pre-processing, model training, and evaluation.

A. Data Collection

We collected a variety of images showcasing bolts in both tilted and standard orientations.

B. Data Annotation

The images were annotated, employing bounding boxes to categorize bolts as either ”Misaligned” or ”normal”.

C. Data Augmentation

Since the dataset contained only a limited number of images, and deep learning demands a large dataset for training, testing, and validation, we employed image augmentation techniques. These techniques included rotation, flipping, grayscale conversion, and saturation adjustment, which helped to expand the dataset and improve its diversity.

D. Data Pre-processing

The images underwent resizing, normalization, and other essential preprocessing steps to ensure they were ready for training.

E. Model Training

You Only Look Once (YOLO) stands out as a highly favored object detection model, renowned for its exceptional speed and performance. Over time, various versions of YOLO have been introduced, each version refining efficiency, performance, and accuracy compared to its predecessors [3]. YOLO version 8 was released in January 2023. YOLO V8 is characterized as anchor-free, predicting fewer boxes and employing a swifter non-maximum suppression (NMS) process [4].
The data was divided into three sets: training, validation, and test. The training set was utilized to train the model, while the validation set was employed to adjust hyperparameters and monitor the model's performance during training. Finally, the test set was used to assess the performance of the finalized model.

F. Model Evaluation

Evaluation metrics like accuracy and confusion matrices were employed to demonstrate the precision of YOLOv8 in classifying the various types of bolts. Figure: 1 shows bolt classification and detection utilizing YOLOv8 bounding boxes, whereas Figure:2 shows the training graphs.

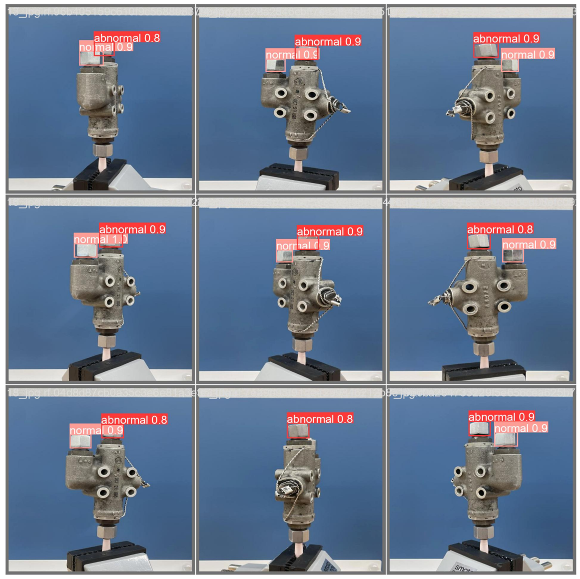

Fig. 1. Shows Bolt clasification

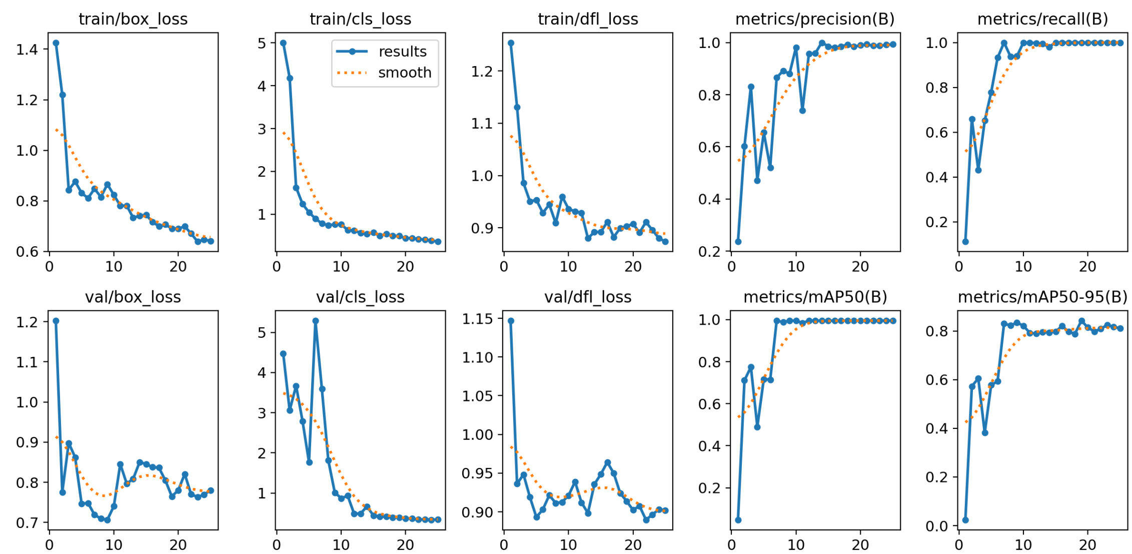

Fig. 2. Shows Training Graphs

III. Conclusion

This paper introduces the application of YOLOv8 for addressing the misaligned bolt detection and classification challenge. Despite being trained on a limited dataset enhanced with data augmentation techniques, YOLOv8 achieves an average accuracy of 90% in the task of detecting and classifying bolts. It is recommended that further research is done to ascertain the performance in a real environment using augmented reality (AR) glasses with the use of a video camera and AI algorithms.

References

[1] X. Zhao, Y. Zhang, and N. Wang, “Bolt loosening angle detection technology using deep learning,” *Structural Control and Health Monitoring*, vol. 26, no. 1, p. e2292, 2019.

[2] D. Song, X. Xu, X. Cui, Y. Ou, and W. Chen, “Bolt looseness detection based on canny edge detection algorithm,” *Concurrency and Computation: Practice and Experience*, vol. 35, no. 21, p. e7713, 2023. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/cpe.7713

[3] Y. Quan, P. Wang, Y. Wang, and X. Jin, “Gui-based yolov8 license plate detection system design,” in *2023 5th International Conference on Control and Robotics (ICCR)*, 2023, pp. 156–161.

[4] J. Solawetz and Francesco, “What is yolov8? the ultimate guide,” Roboflow Blog, 2023, January 11, [Accessed 2024]. [Online]. Available: https://blog.roboflow.com/whats-new-in-yolov8/