

tyre detection

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ABSTRACT

Tire defects, such as cuts, bulges, and punctures, pose significant safety risks to vehicles and passengers. Early detection of these defects is crucial for maintaining road safety and preventing accidents. However, manual inspection of tires for defects is time-consuming, labor-intensive, and prone to human error. Therefore, there is a need for an automated tire defect detection system that can accurately and efficiently identify various types of defects in real-time. The YOLOv8 algorithm, an evolution of the popular You Only Look Once (YOLO) object detection family, is particularly well-suited for real-time tire defect detection in images. Its key strength lies in its ability to detect multiple objects within an image simultaneously with high accuracy and speed. This is achieved through a single neural network that divides the image into regions and predicts bounding boxes and probabilities for each region. In the context of tire defect detection, YOLOv8 can be trained to recognize various types of defects such as cuts, bulges, and punctures. By utilizing its efficient architecture and real-time processing capabilities, YOLOv8 can help improve road safety by enabling automated and rapid detection of tire defects, allowing for timely maintenance and replacement of damaged tires.

CHAPTER 1

INTRODUCTION

1.1 TYRE DEFECTS DETECTION

Tire defects are a significant concern for vehicle safety, as they can lead to accidents, breakdowns, and increased maintenance costs. Common tire defects include cuts, punctures, bulges, and uneven wear, which can compromise the structural integrity of the tire and increase the risk of blowouts. Traditional methods of detecting tire defects rely on manual inspection, which is time-consuming, labor-intensive, and prone to human error. As a result, there is a growing interest in developing automated systems for tire defect detection. Automated tire defect detection systems use image processing techniques to analyze digital images of tires and identify defects. In which the systems can provide more accurate and consistent results compared to manual inspection methods, leading to improved safety and reduced maintenance costs. This project focuses on the development of an automated tire defect detection system using image processing techniques. The system aims to detect common tire defects such as cuts, punctures, and bulges, as well as more complex defects such as uneven wear patterns. By automating the detection process, the system can provide faster and more reliable results, helping to ensure the safety of vehicles on the road.

1.2 DIFFERENT APPROACHES FOR TYRE DEFECT DETECTION

1.2.1 Visual Inspection:

This is the most basic method, where trained inspectors visually examine tires for defects such as cuts, punctures, bulges, and uneven wear. While simple, this method is subjective and can be prone to human error.

1.2.2 Ultrasound Testing:

Ultrasound waves are used to detect defects within the tire structure. This method can detect internal defects such as delamination and air leaks, but it requires specialized equipment and training.

1.2.3 X-ray Inspection:

X-ray imaging can be used to inspect the internal structure of tires for defects. This method is effective for detecting internal defects but requires expensive equipment and specialized training.

1.2.4 Automated Optical Inspection (AOI):

AOI systems use cameras and image processing algorithms to inspect tires for defects. These systems can detect a wide range of defects, including cuts, punctures, and bulges, and can operate at high speeds. However, they can be expensive to implement and require regular maintenance.

1.2.5 Infrared Thermography:

This method uses infrared cameras to detect heat variations on the tire surface, which can indicate defects such as delamination or air leaks. It is non-contact and can be used for real-time monitoring.

1.2.6 Acoustic Emission Testing:

This method detects defects by analyzing the acoustic signals emitted by the tire when under stress. It can detect defects such as cracks and delamination, but it requires specialized equipment and expertise.

1.2.7 Pressure Testing:

By inflating the tire to a specified pressure and monitoring pressure changes over time, defects such as punctures and leaks can be detected. This method is simple and cost-effective but may not detect all types of defects.

CHAPTER 3 PROJECT DESCRIPTION

3.1 INTRODUCTION

Tire defects pose a serious safety risk for vehicles, necessitating efficient detection methods. Manual inspection is time-consuming and prone to errors. This project proposes a tire defect detection system using the YOLOv8 algorithm, known for its speed and accuracy in object detection. Integrating this algorithm with Visual Studio will streamline development and deployment processes, enhancing the system's overall efficiency and effectiveness.

The primary goal of this project is to develop a computer vision system that can automatically detect and classify tire defects, including cuts, bulges, and wear patterns, in real time. By leveraging YOLOv8's capabilities and integrating it into Visual Studio, the system aims to improve the speed and accuracy of defect detection, thereby enhancing vehicle safety and reducing the risk of accidents caused by tire defects.

The implementation will involve training the YOLOv8 model on a dataset of annotated tire images to recognize various defect types. Visual Studio will be used to integrate the trained model into a user-friendly application that can process images from a camera installed in a production line or inspection area. The system's effectiveness will be evaluated based on its ability to accurately detect and classify tire defects under various conditions, such as different lighting and tire wear levels.

3.2 PROBLEM STATEMENT

The desire for tire defect detection arises from the critical role tires play in vehicle safety and the challenges associated with manually inspecting them. Automated tire defect detection systems aim to enhance safety by identifying defects such as bubbles, peeling, impurities, bulging, and cracks early, preventing potential hazards on the road. The systems also increase driver awareness, encourage regular tire checks, and promote adherence to proper tire change times, reducing the risk of sudden tire failures or punctures.

3.3 BLOCK DIAGRAM

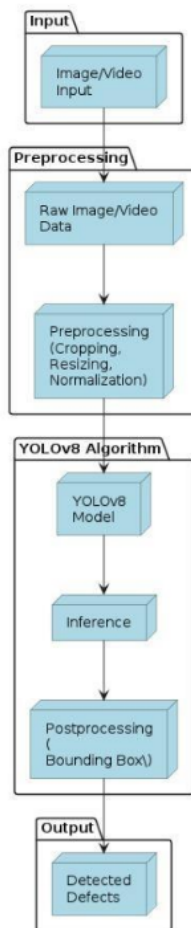


Figure 3.3.1: Block diagram for Tire Defect Detection.

3.4 MODULES

3.3.1 TRAINING DATASET:

Extracting the dataset along with the images and annotated labels and pre-training it in Roboflow. The pre-trained dataset is uploaded in the drive for training the model.

3.3.2 TRAINING YOLOv8 MODEL:

By using the predetermined package ‘Ultralytics’ to train the yolo models for object detection. Here, the light weight yolov8n.pt model is used and trained in google colab.

3.3.3 CONVERTING YOLO TO TENSOR FLOW LITE:

The trained yolo model is then converted to TFLite model for integrating it in the web/apps.

3.3.4 INTEGRATING THE TRAINED MODEL:

To integrate the trained model in, there is an ASP.NET in Visual Studio for integrating the Tensorflow model.

3.4 MERITS AND DEMERITS

3.4.1 MERITS:

- 1. Improved Accuracy:** Research on tire defect detection using machine vision, deep learning, and transfer learning methods has shown significant improvements in accuracy compared to traditional manual inspection methods.
- 2. Efficiency and Automation:** Implementing machine vision and deep learning technologies for tire defect detection allows for automatic and reliable inspection, reducing labor costs, and improving tire quality by eliminating the need for manual inspection, which can be subjective and time-consuming.
- 3. Safety Enhancement:** Detecting tire defects accurately is crucial for ensuring driving safety, as even minor defects on tires can lead to major accidents. Advanced detection methods help in identifying defects that may not be easily visible to the human eye, thereby enhancing safety on the roads.
- 4. Cost-Effectiveness:** By utilizing machine vision and deep learning technologies, tire manufacturers can reduce the number of returned tires due to defects, leading to cost savings and increased efficiency in the production process.
- 5. Diverse Defect Detection:** Advanced methods can detect various types of tire defects, including cracks, bubbles, impurities, and bulges, providing a comprehensive solution for ensuring tire quality and safety

3.4.2 DEMERITS:

- 1. Limitations in Detecting Diverse Defects:** While advanced technologies like deep learning show high accuracy in detecting specific tire defects like cracks, they may have limitations in identifying a wide range of defects such as air bubbles, foreign objects, and other complex issues.

- 2. Dependency on Specific Data:** ¹ Tire defect detection systems based on deep learning often require extensive training datasets to ensure accurate detection. In industrial scenarios where certain defect types are rare, the effectiveness of these systems can be compromised due to insufficient training samples.
- 3. Challenges in Anomaly Detection:** Anomaly detection methods, although useful for identifying outliers in defect-free samples, may face challenges in efficiently mining information from a large number of defect-free images and training models to accurately detect anomalies in tire defects.
- 4. Complexity and Cost:** Implementing advanced tire defect detection systems, especially those based on deep learning and machine vision, can involve significant complexity in terms of setup, maintenance, and cost, which may pose challenges for some tire manufacturers or inspection facilities.

3.5 APPLICATIONS:

- 1. Automotive Industry:** Tire defect detection systems are crucial in the automotive industry for ensuring the quality and safety of tires used in vehicles. By accurately identifying defects like cracks, bubbles, impurities, and bulges, these systems contribute to enhancing driving safety and reducing the risk of accidents.
- 2. Tire Manufacturing:** In tire factories, tire defect detection technologies play a vital role in quality control processes. By automating the inspection of tire surfaces for defects, these ⁹ systems improve efficiency, reduce labor costs, and enhance the overall quality of tires produced.

3. Driver Awareness: Implementing visual tire inspection systems can increase driver awareness about the importance of monitoring tire conditions regularly. By alerting drivers to potential defects like aging, oxidation, and cracking, these systems promote ¹adherence to proper tire maintenance practices, ultimately reducing the risk of tire-related accidents.

4. Industrial Applications: Machine vision detection technology, including tire defect detection systems, ¹is widely used in various industrial applications due to its non-contact nature, wide visual range, high reliability, and cost-effectiveness. These systems are instrumental in automating defect detection processes and improving overall product quality in industrial settings.

RESULTS AND DISCUSSION

4.1 PRECISION

The precision metrics in the provided plots evaluate the accuracy of object localization in a computer vision model trained for object detection using YOLOv8. They indicate how well the model identifies and delineates objects within images. The increasing trend observed in precision (B) and mAP metrics over training epochs suggests improved performance in object detection as training progresses, but further analysis considering factors like dataset quality and model architecture is necessary for a comprehensive assessment.

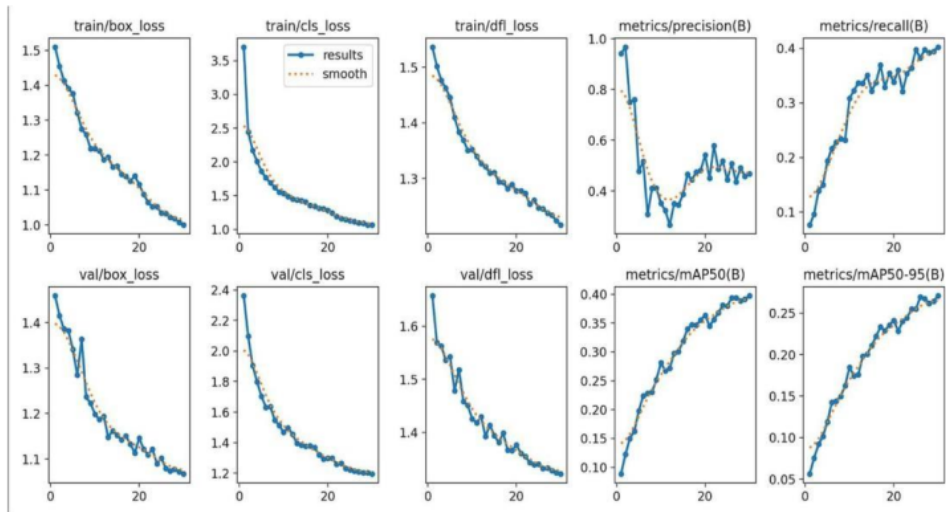


Figure 4.1.1: Precision graph of YOLOv8 model.

4.2 CONFUSION MATRIX:

The confusion matrix provides an overview of the classification model's performance in predicting various classes. Darker squares along the diagonal indicate accurate predictions, while lighter squares off the diagonal represent misclassifications. Analyzing the matrix helps identify which classes the model predicts well and where it struggles, guiding improvements in its performance.

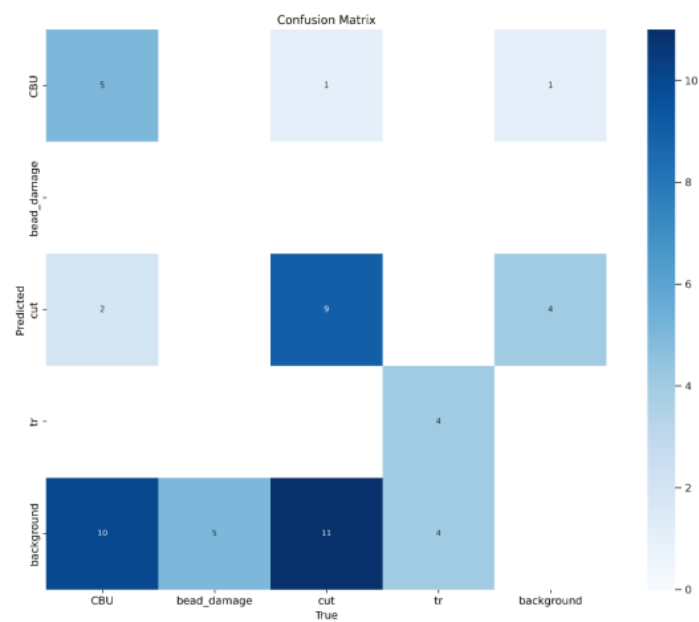


Figure 4.2.1 Confusion Matrix of YOLOv8 model.

5 CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION:

In conclusion, tire defect detection using the YOLOv8 algorithm offers a powerful solution for enhancing vehicle safety. YOLOv8 provides real-time detection with high accuracy and efficiency, making it ideal for quickly identifying various tire defects such as cuts, bulges, and wear patterns. Its versatility and ease of integration make it a practical choice for integration into existing systems or standalone applications. Overall, YOLOv8's capabilities make it a valuable tool for improving vehicle safety and preventing accidents caused by tire defects.

5.2 FUTURE SCOPES:

1. **Enhanced Sensor Technology:** Integration of advanced sensor technologies, such as 3D imaging and hyperspectral imaging, could provide more detailed information about tire conditions, leading to better defect detection.
2. **IoT and Connectivity:** Integration of tire defect detection systems with IoT devices and cloud computing could enable real-time monitoring of tire conditions and predictive maintenance, enhancing vehicle safety and efficiency.
3. **Autonomous Vehicles:** Tire defect detection will be crucial for the safe operation of autonomous vehicles, driving the need for more robust and reliable detection systems.
4. **Data-driven Insights:** Utilizing data analytics and artificial intelligence to analyze tire defect data could provide valuable insights for improving tire design, manufacturing processes, and overall vehicle safety.
5. **Augmented Reality (AR) and Virtual Reality (VR):** Integration of AR/VR technologies could enhance the visualization of tire defects, aiding in training and improving the efficiency of inspection processes.

APPENDICES

APPENDIX 1

SOFTWARE TOOLS

1. **Visual Studio:** This is the main software where this project is fully implemented. The Visual Studio which is an open-source software for developing web, applications. here, the web , user integration and model integration are done in Visual Studio.
2. **OpenAI API:** This API is free provided by OpenAI, where the chatbot is created and integrated in the Android Studio.
3. **YOLOv8:** The YOLOv8 (You Only Look at Once version 8) provided by Ultralytics which is used for detecting the ingredients and providing the bounding boxes while detection.
4. **Python:** The python which is a versatile programming language which is commonly used for machine learning and data science. Here the python programming language is used to train the YOLO model and used to convert it into TensorFlow model.
5. **Image Processing Libraries:** The image processing libraries for accessing the camera in the application by using the OpenCV libraries.

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