Project Report: Industrial Equipment Defect Classification

Problem Statement:

The objective of this project is to develop a machine learning model that can classify images of industrial equipment into two categories: 'defective' and 'non-defective'. The dataset contains images labeled as 'defective' or 'non-defective', with additional labels for the type of defect in defective images. The challenges include dealing with class imbalance, selecting appropriate preprocessing techniques, and choosing the best model architecture for accurate classification.

Methodology:

1. Data Collection: The dataset consists of images of industrial equipment, categorized into defective and non-defective classes. The images are pre-labeled based on their defect status.

2. Data Preprocessing:

- The dataset is split into training, validation, and test sets.
- Image augmentation techniques such as horizontal flip, vertical flip, rotation, and brightness adjustment are applied to increase the diversity of the training data.
- The images are resized to a uniform size of (300, 300) pixels and normalized to [0, 1] range.

3. Model Selection: Several pre-trained convolutional neural network (CNN) architectures, including ResNet152V2, Xception, InceptionResNetV2, and ResNet50, are considered for feature extraction.

4. Model Training: The selected model (ResNet152V2) is fine-tuned using the training dataset. The model is compiled with binary cross-entropy loss and evaluated using accuracy, AUC, precision, and recall metrics.

5. Model Evaluation: The trained model is evaluated on the test set to assess its performance. Classification metrics such as accuracy, precision, recall, and AUC are computed, and a confusion matrix is generated to visualize the model's performance.

Model Performance:

- Training Time: The model took approximately **1 hour and 29 minutes** to train on the training dataset.
- Evaluation Time: The evaluation of the model on the test set took **approximately 5 minutes.**
- Training Accuracy: The model achieved **a training accuracy of 94.39%** during the final epoch of training, indicating its ability to accurately classify industrial equipment images.
- Test Accuracy: The model achieved a **test accuracy of 98.30%,** indicating its ability to accurately classify industrial equipment images.
- Test AUC: The area under **the ROC curve (AUC) is 0.9984**, indicating high discriminatory power.
- Precision and Recall: The model achieved a **precision of 1.0000 and recall of 0.9729,** indicating a high true positive rate with very few false positives.

Insights:

- The **ResNet152V2 model** demonstrates excellent performance in classifying industrial equipment images as defective or non-defective.
- The model's **high precision and recall scores** indicate its effectiveness in identifying defective equipment while **minimizing false positives.**
- Despite the class imbalance in the dataset, with more defective images than non-defective ones, the model shows **balanced performance in classifying both classes.** This indicates that the model can effectively handle class imbalance, which is a common challenge in binary classification tasks.

Conclusion:

The developed machine learning model based on the ResNet152V2 architecture successfully classifies images of industrial equipment into defective and non-defective categories with high accuracy, precision, and recall. The model's performance indicates its potential for practical applications in industrial defect detection and quality assurance.