Student Name: Nimra Akram
Roll No: F22BINFT1E02045
Supervisor: Dr. Musarat Karim

Project Title: Automated PCB Defect Detection Using Deep Learning

Project Brief

The Automated PCB Defect Detection System aims to develop a deep learning-based solution for identifying manufacturing defects on Printed Circuit Boards (PCBs) using image processing and object detection techniques. This project utilizes the PCB Defects dataset from Kaggle, which contains labeled images of various PCB defects such as open circuits, shorts, missing holes, spurs, mousebites, and copper defects. The system will train a YOLOv8 deep learning model to automatically detect and classify these defects from PCB images. The goal of this project is to automate PCB quality inspection, reduce human error, and improve efficiency in the electronics manufacturing process. The system will serve as a step toward smart manufacturing and quality control under the framework of Industry 4.0.

Objectives

• To develop an intelligent defect detection model for PCB images using deep learning.
• To train and validate a YOLOv8 model using the Kaggle PCB Defects dataset.
• To automate the detection and classification of different PCB defect types.
• To minimize manual inspection time and reduce production errors.
• To provide a visual interface to display detection results for each PCB image.

Scope of the Project

• The system will use a deep learning-based object detection model (YOLOv8).
• It will detect and classify defects in PCB images into predefined categories.
• The model will be trained using a labeled dataset of defective and non-defective PCB images.
• The project will include data preprocessing, model training, validation, and testing phases.
• The trained model will be able to process new PCB images and highlight detected defects with bounding boxes.
• A future extension may include deployment of the model in a real-time inspection system using cameras in production lines.

Dataset Description

Dataset Name: PCB Defects Dataset (Kaggle)

Dataset Overview:
The dataset contains images of PCB sections categorized into six major defect types:
• Open – Unconnected circuit paths.
• Short – Unintended connections between traces.
• Mousebite – Small cuts or missing copper areas.
• Spur – Thin unwanted copper protrusions.
• Missing Hole – Drilled holes not present.
• Copper – Unwanted leftover copper areas.

Each image is labeled with its defect type and stored in class folders. The dataset is divided into training, validation, and test sets for effective model performance evaluation.

Proposed Modules

1. **Data Preparation Module**
• Collect and preprocess images from the Kaggle PCB Defects dataset.
• Convert data into YOLO-compatible format (.jpg and .txt annotations).
• Split dataset into training, validation, and testing subsets.

2. **Model Training Module**
• Train the YOLOv8 model on the training set.
• Validate performance using metrics such as Precision, Recall, mAP@50, and mAP@95.
• Optimize hyperparameters for best results.

3. **Defect Detection Module**
• Use the trained model to predict defects in unseen PCB images.
• Highlight defects using bounding boxes and labels.
• Display output with classification confidence.

4. **Evaluation and Visualization Module**
• Generate performance reports and confusion matrices.
• Visualize detection results for validation and testing datasets.

Technology Stack

Component	Technology
Programming Language	Python
Deep Learning Framework	PyTorch / Ultralytics YOLOv8
Data Processing	OpenCV, NumPy, Pandas
Visualization Tools	Matplotlib, Seaborn
IDE / Tools	Jupyter Notebook, VS Code
Dataset Source	Kaggle – PCB Defects Dataset

Expected Outcomes

• A trained YOLOv8 model capable of detecting multiple PCB defect types.
• An automated image inspection system reducing manual inspection time.
• Improved defect detection accuracy compared to traditional visual inspection methods.
• A foundation for industrial PCB quality control automation.

Future Enhancements

• Integration with real-time camera systems for live PCB defect detection.
• Development of a web or mobile interface for inspection results visualization.
• Expansion to detect defects in multi-layer or complex PCBs.
• Implementation of cloud-based deployment for industry usage.