AI BASED SMART INSPECTION OF PCBS FOR DEFECT DETECTION

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Keywords:

Artificial Intelligence, Computer Vision, XY Plotter

Introduction:

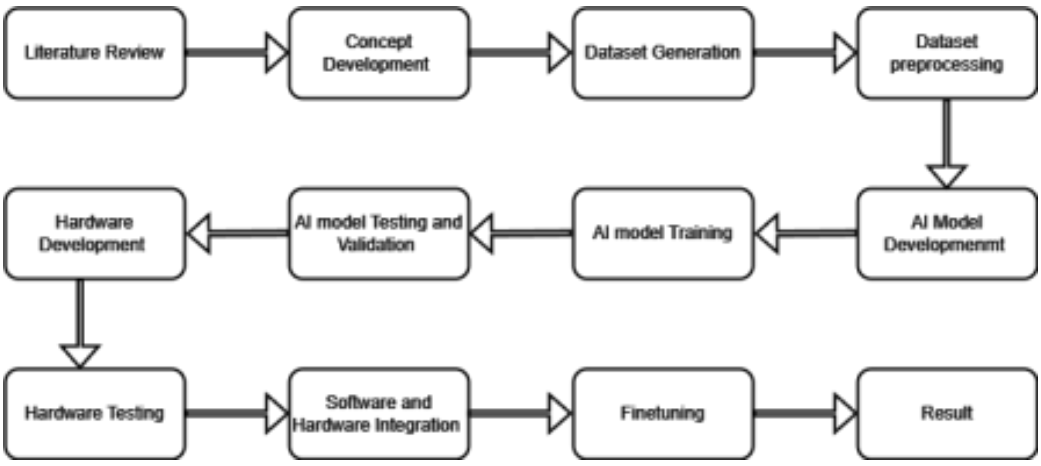
The project "AI-based Smart Inspection of PCBs for Defect Detection" focuses on developing an automated system for identifying defects in printed circuit boards (PCBs) using machine learning and object detection techniques. A Cartesian robot, equipped with high-resolution cameras, captures images of PCBs to ensure accurate data acquisition. The AI model analyzes these images to detect anomalies like missing components, soldering errors, or cracks. By reducing human involvement in the inspection process, the system enhances accuracy, minimizes errors, and accelerates defect detection. The real-time analysis enables prompt identification and classification of defects, improving the overall manufacturing quality. Additionally, the project promotes cost-effective quality control and ensures product reliability across various electronic devices. Designed to be scalable and customizable, this solution addresses industry needs for efficient defect detection and aligns with sustainability goals by reducing waste. It also offers valuable learning opportunities in AI and robotics for students and researchers.

Objectives:

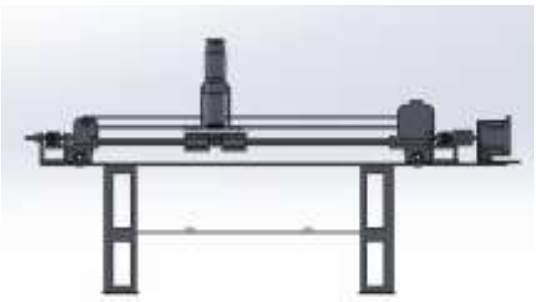
- Develop an automated inspection system for PCBs that reduces the reliance on manual labor.
- Improved efficiency in automated detection so that even the smallest anomalies are identified promptly.
- Cost-effective quality control measures.
- Mitigate potential risks to end-users.

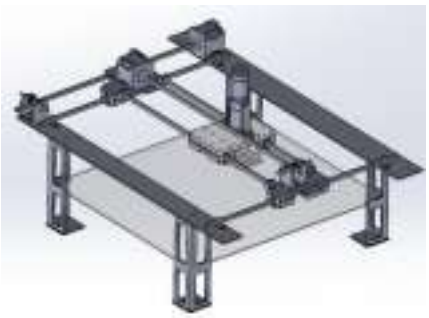
Methodology:

The methodology of this project includes several key stages toward the development of an automated defect detection system for PCBs based on machine learning and object KSCST: Student Project Programme: 48th series: 2024-2025 3 detection techniques. The methodology for the PCB defect detection project integrates both software and hardware components, ensuring a comprehensive approach to automating the defect detection process. The process begins with data collection and preprocessing, where high-resolution images of PCBs are captured. These images, which include both defective non-defective samples, are labeled to identify the location and types of defects.Preprocessing involves formatting, resizing, and normalizing the images to ensure they are suitable for training an object detection model. This preparation allows the machine learning algorithm to learn effectively from consistent and well-structured data.



The hardware component of the system includes a Cartesian robot equipped with XY plotting capabilities, which plays a critical role in automating the image capture process. The Cartesian robot is programmed to move precisely along the X and Y Axis to scan and capture PCB images with high accuracy. This ensures uniform image acquisition, reducing variability and enhancing the quality of the dataset. The robot's precise movements allow it to focus on specific regions of interest on the PCB, enabling detailed inspection and ensuring that even minute defects are detected. After collecting the data, the project moves to model selection and training. A Suitable Object detection algorithm, such as SSD (Single Shot Detector) is selected to identify defects on PCBs. The labelled dataset is used to train the model, where it learns to classify and locate defects such as missing components, soldering errors, or cracks. The trained model is then integrated with the Cartesian robot, allowing real-time defect detection during PCB inspections. In the defect detection phase, the model analyses new PCB images captured by the robot. The Cartesian robot continuously moves across the PCB surface, capturing and feeding images into the detection system. The system identifies defects, marking them on the image and classifying their types. Metrics such as accuracy, precision, and recall aroused evaluate the performance of the integrated system. Based on the results, further refinements can be made to either the hardware (e.g., improving robot precision) or the software(e.g., enhancing the model's performance). By combining advanced software with precision hardware, this methodology offers an efficient and automated solution for PCB defect detection. The Cartesian robot ensures KSCST: Student Project Programme: 48th series: 2024-2025 4 consistent and high-quality image acquisition, while the object detection model provides accurate and reliable defect identification, significantly improving the quality control processing





Result and Conclusion:

- Identification of manufacturing defects in PCBs, such as broken traces, missing components, soldering errors, or short circuits, using image analysis and machine learning techniques.
- Categorization of detected defects into predefined classes (e.g., solder issues, misaligned components, etc.) with high precision.
- The system should process PCB images in real-time or near real-time for defect detection and classification.
- A user-friendly visualization interface displaying the PCB with highlighted defect areas, defect type, and severity.
- Enhanced inspection accuracy compared to manual inspection, leading to improve manufacturing quality and reduced faulty outputs

Future Scope:

- Develop an automated inspection system for PCBs that reduces the reliance on manual labor.
- Improved efficiency in automated detection so that even the smallest anomalies are identified promptly.
- Cost-effective quality control measures.
- Mitigate potential risks to end-users.