CircuitGuard – PCB Defect Detection and Classification Application

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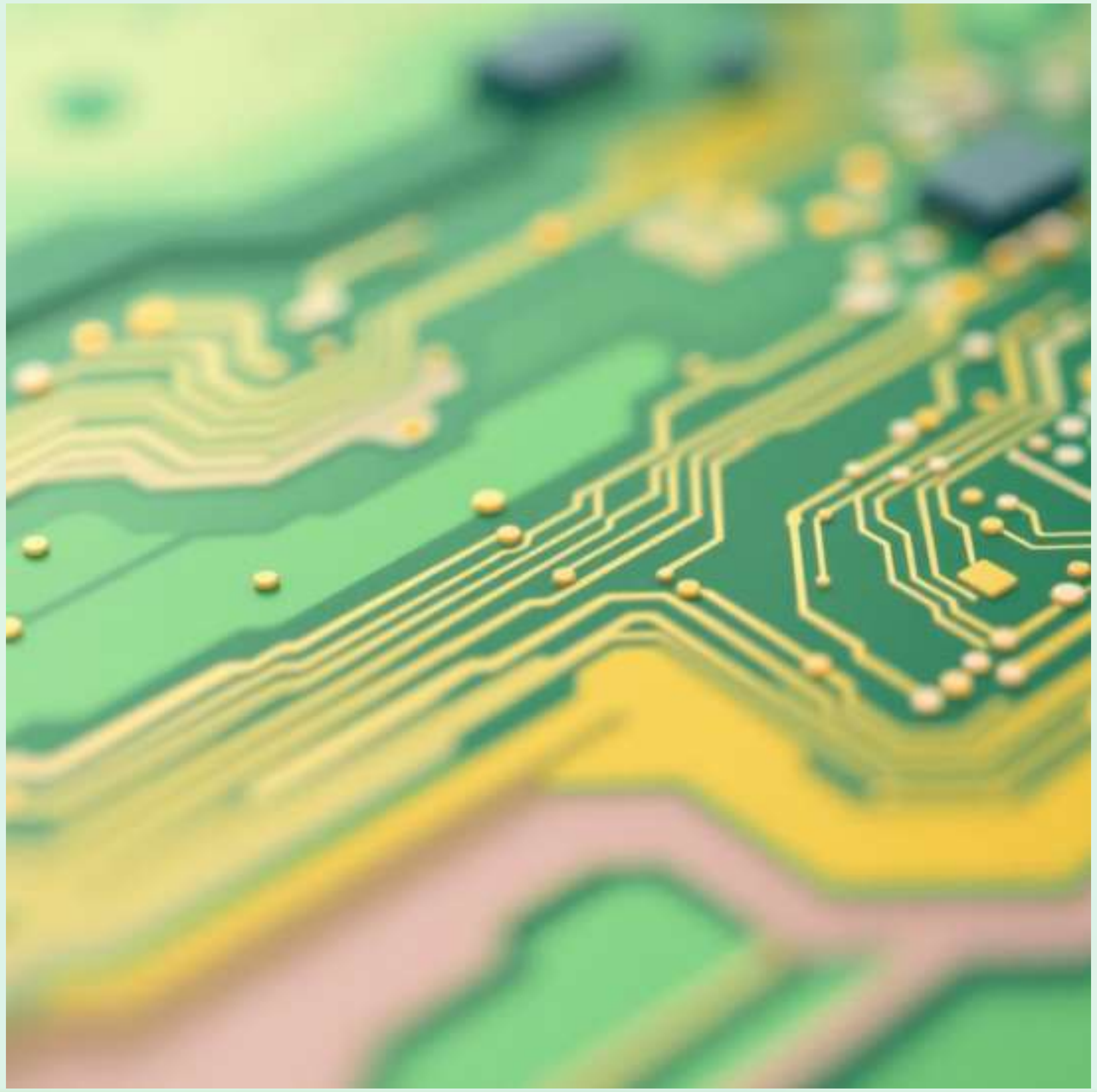
Introduction: PCB Inspection

What is a PCB?

A Printed Circuit Board (PCB) is the foundational component in nearly all modern electronics, providing mechanical support and electrical connections for electronic components.



Why Defect Detection Matters

Ensuring the quality of PCBs is critical. Defects can lead to product failure, safety hazards, and significant manufacturing costs. Accurate detection guarantees reliability.

Challenges of Manual Inspection

- Slow and labor-intensive processes
- High susceptibility to human error and fatigue
- Inconsistent detection quality across inspectors

There's a growing need for automation to overcome these limitations.

The Problem: Limitations of Current Inspection Methods

Slow & Error-Prone

Manual inspection is inherently inefficient and susceptible to human oversight, leading to missed defects and production bottlenecks.

Tiny Defects Go Unnoticed

Microscopic flaws and subtle anomalies are extremely difficult for the human eye to consistently identify, impacting product reliability.

Inconsistent Results

Variability among inspectors leads to fluctuating quality control and a lack of standardized defect detection.

Demand for Intelligent Systems

The complexity of modern PCBs necessitates an advanced, intelligent system capable of reliable and consistent defect identification.

Project Objectives: Enhancing PCB Quality Control

1. ### Detect PCB Defects

   Develop a robust system to accurately identify various types of defects present on Printed Circuit Boards.

2. ### Localize Defect Regions

   Precisely pinpoint the exact locations of detected defects on the PCB surface for targeted remediation.

3. ### Classify Defects with CNN

   Utilize a Convolutional Neural Network (CNN) to categorize defects into predefined types, enabling informed corrective actions.

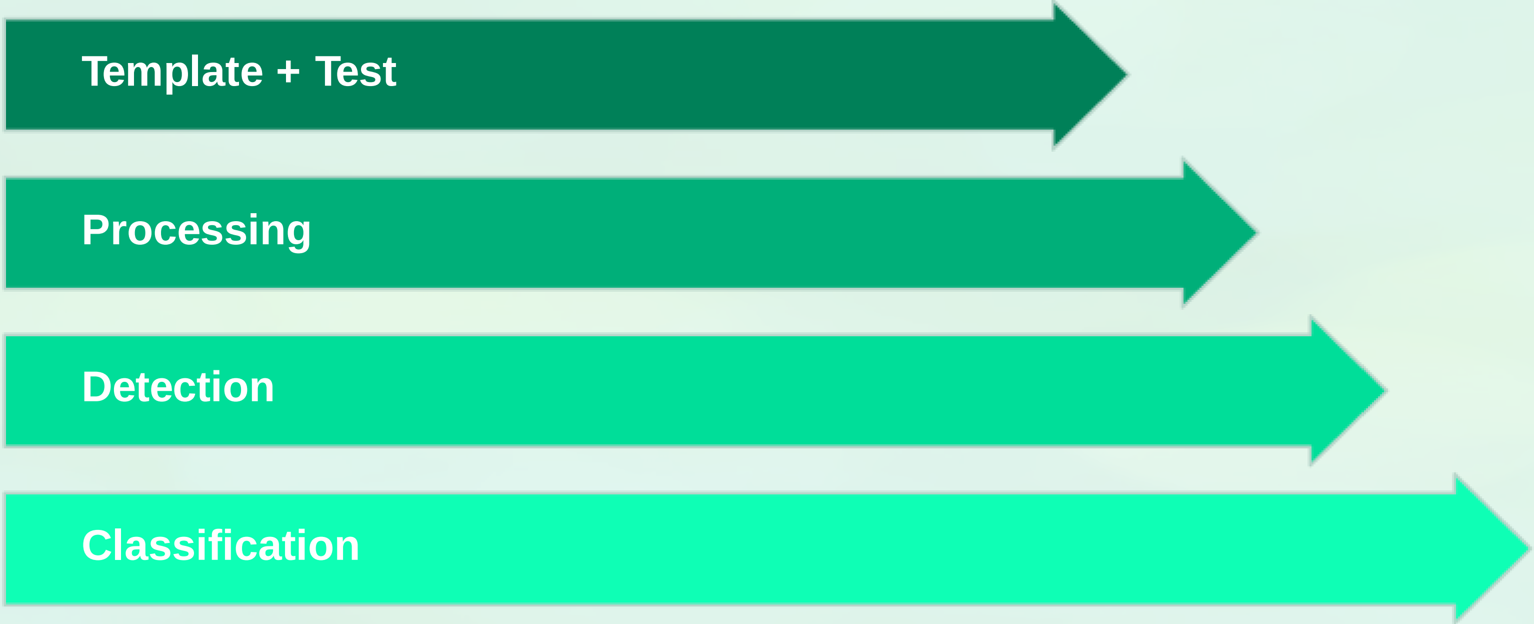
4. ### Build Intuitive Frontend

   Create a user-friendly interface for seamless interaction, allowing easy input of images and display of results.

5. ### Deliver Labeled Results

   Present clear, labeled output images highlighting defects and their classifications, aiding in quick decision-making.

System Overview: CircuitGuard's AI-Powered Pipeline



Template + Test

Processing

Detection

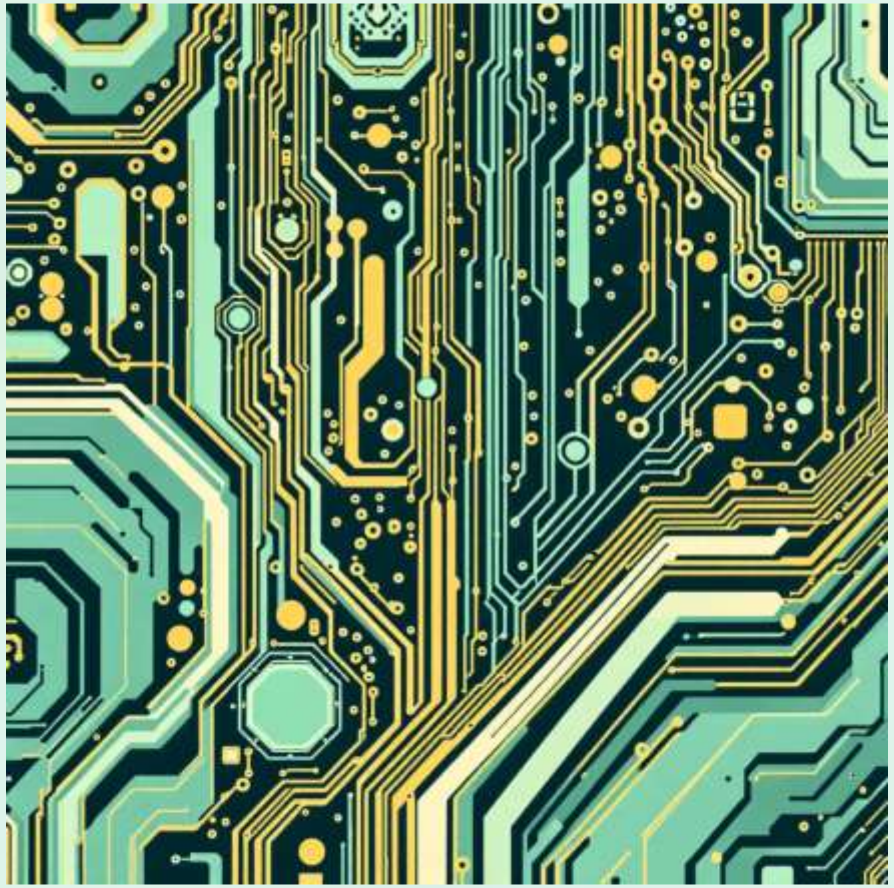
Classification

Dataset Description: Powering AI with DeepPCB

The DeepPCB Dataset

Our project leverages the comprehensive DeepPCB dataset, specifically designed for PCB defect detection.

- Contains both **template** (defect-free) and **test** (potentially defective) images.
- Features various real-world PCB images with diverse layouts and complexities.



Defect Categories

The dataset includes a wide range of common PCB defects, crucial for training a robust classification model:

- Open Circuit
- Short Circuit
- Spurious Copper
- Missing Hole
- Mouse Bite
- Spur

Importance of Labeled Data

A meticulously labeled dataset is vital for supervised learning, enabling the CNN to learn and distinguish between normal features and specific defect types with high accuracy.

Weekly Progress: Foundation & Processing

Step-by-Step Implementation

1

Week 1: Dataset Preparation

- Thorough dataset exploration
- Implemented template-test matching algorithms
- Precise image alignment techniques
- Deep understanding of various defect types

2

Week 2: Image Processing

- Executed robust image subtraction for difference mapping
- Applied Otsu thresholding for binarization
- Integrated noise removal algorithms
- Successfully generated preliminary defect maps

Weekly Progress: Detection & Training

1

Week 3: ROI & Contour Detection

- Leveraged OpenCV contours for defect outlines
- Implemented precise bounding box extraction
- Developed efficient ROI cropping strategies
- Completed initial labeling of extracted regions

2

Week 4: Model Training

- Selected EfficientNet-B4 as the core CNN architecture
- Implemented model in PyTorch framework
- Processed images to 128x128 resolution for training
- Configured Adam optimizer and Cross-entropy loss

Weekly Progress: Evaluation & Deployment

Refining and Delivering the Solution

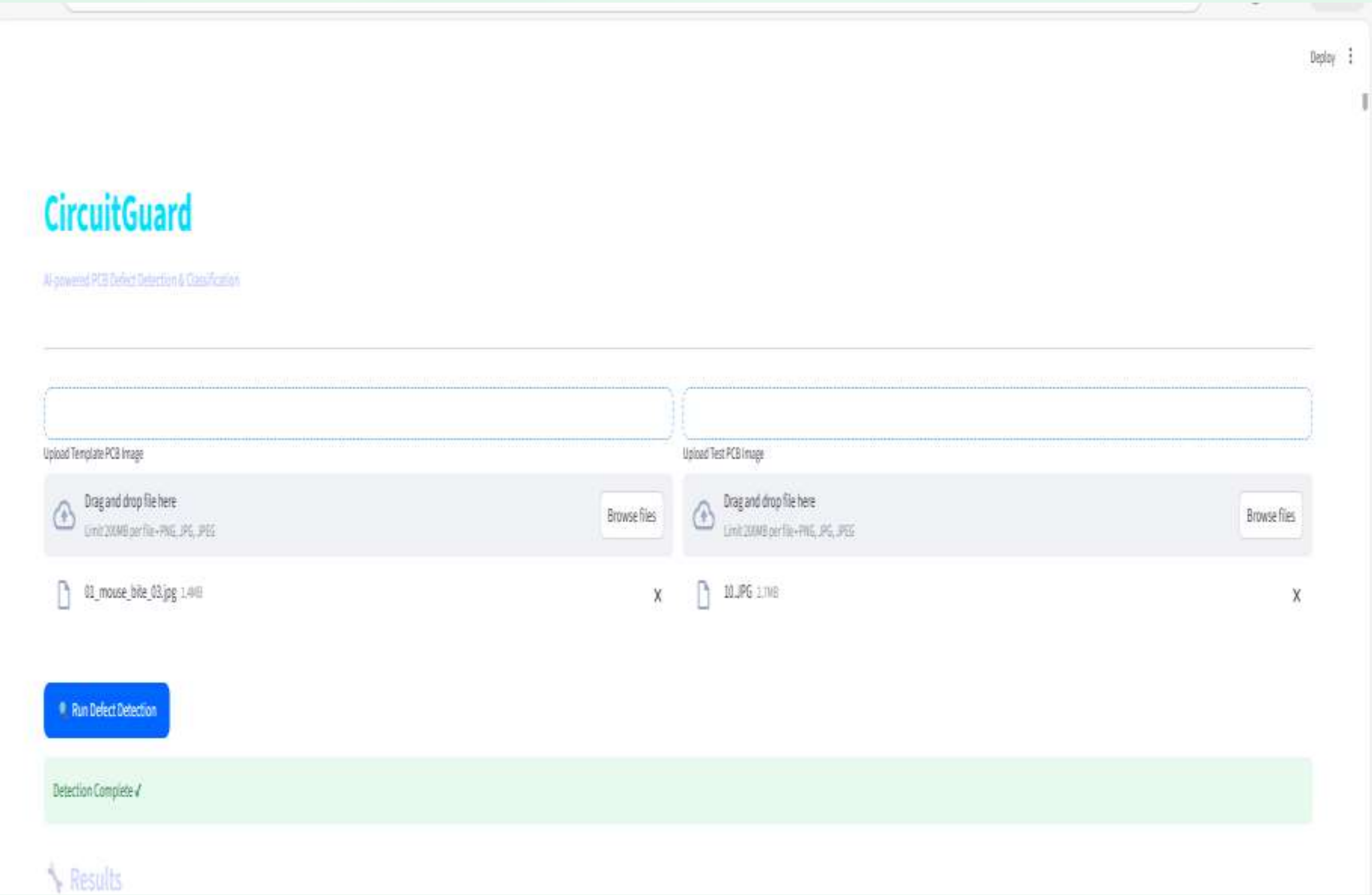
1 Week 5: Model Evaluation

- Rigorous testing on new, unseen images
- Generated confusion matrices for performance analysis
- Conducted comprehensive accuracy testing
- Performed detailed error analysis to identify areas for improvement

2 Week 6: Frontend Development

- Designed intuitive Streamlit / Web UI
- Developed user-friendly image upload interface
- Implemented clear output display for defect visualization
- Ensured seamless user interaction and experience

Result :-



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AI-powered PCB Defect Detection & Classification

Upload Template PCB Image

Drag and drop file here
Limit 200MB per file • PNG, JPG, JPEG

01_mouse_bite_03.jpg 1.4MB

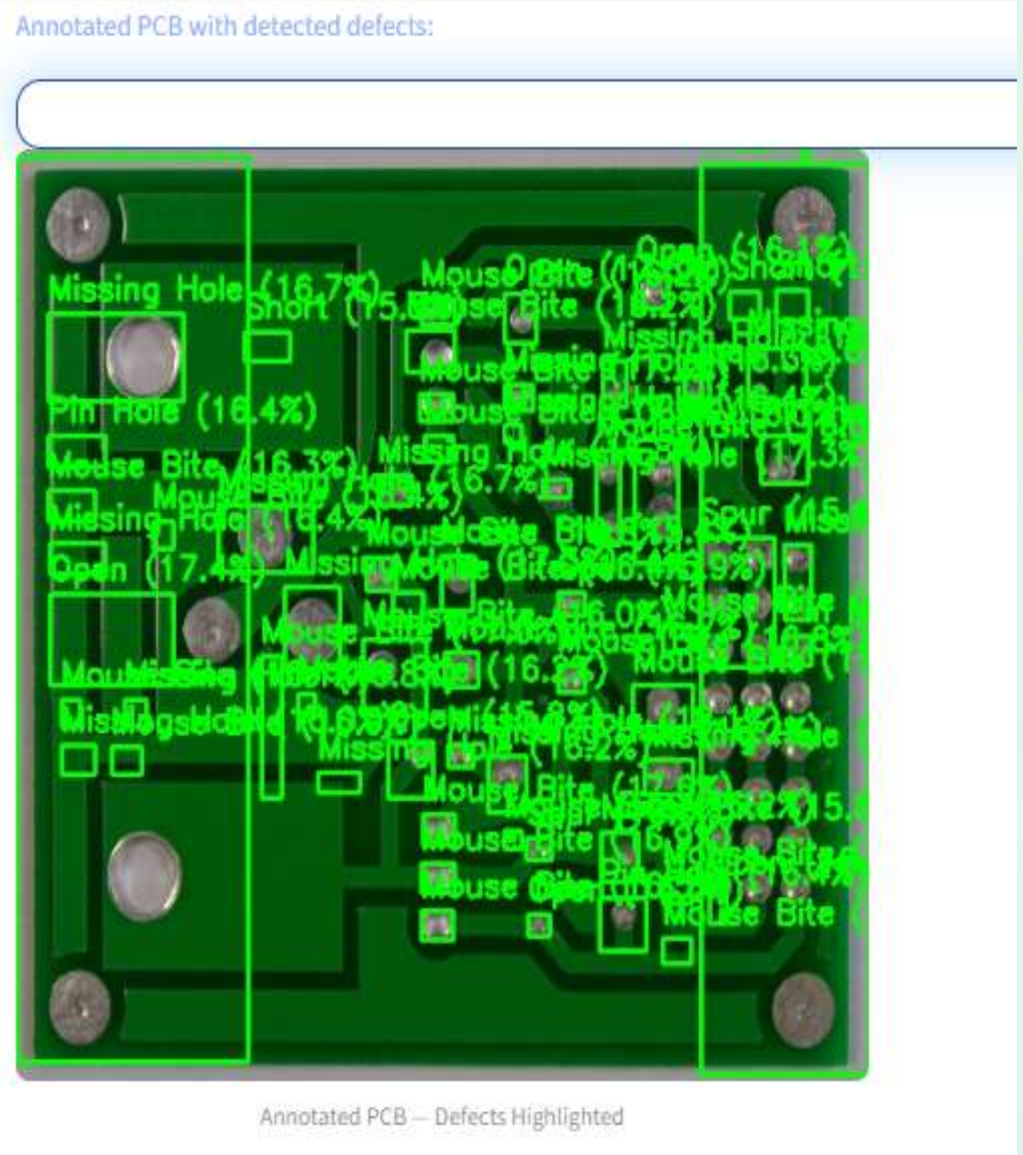
Upload Test PCB Image

Drag and drop file here
Limit 200MB per file • PNG, JPG, JPEG

10.JPG 1.7MB

Detection Complete ✓

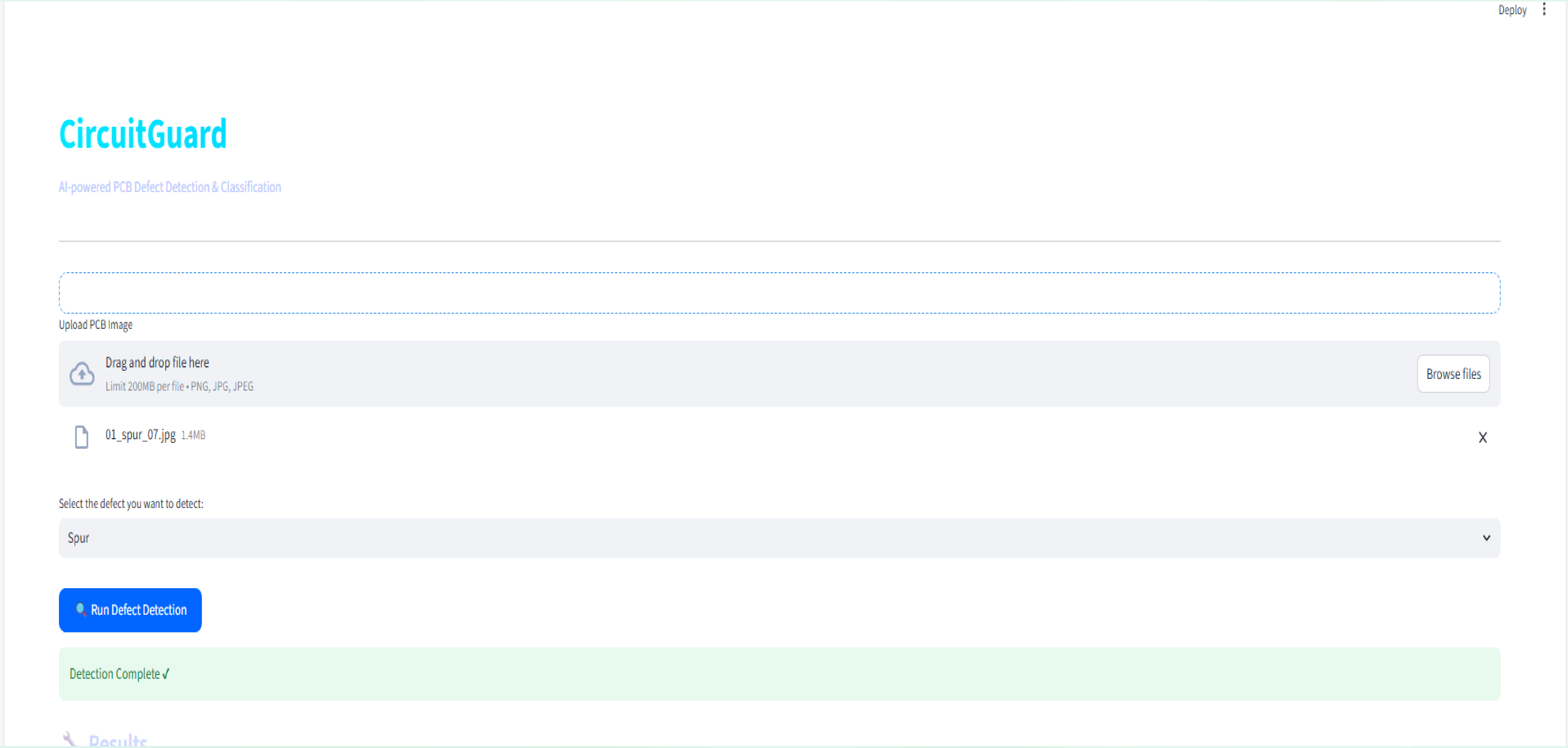
Results



Annotated PCB with detected defects:

Annotated PCB — Defects Highlighted

Result :-Updated Result



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AI-powered PCB Defect Detection & Classification

Upload PCB Image

Drag and drop file here

Limit 200MB per file • PNG, JPG, JPEG

01_spur_07.jpg 1.4MB

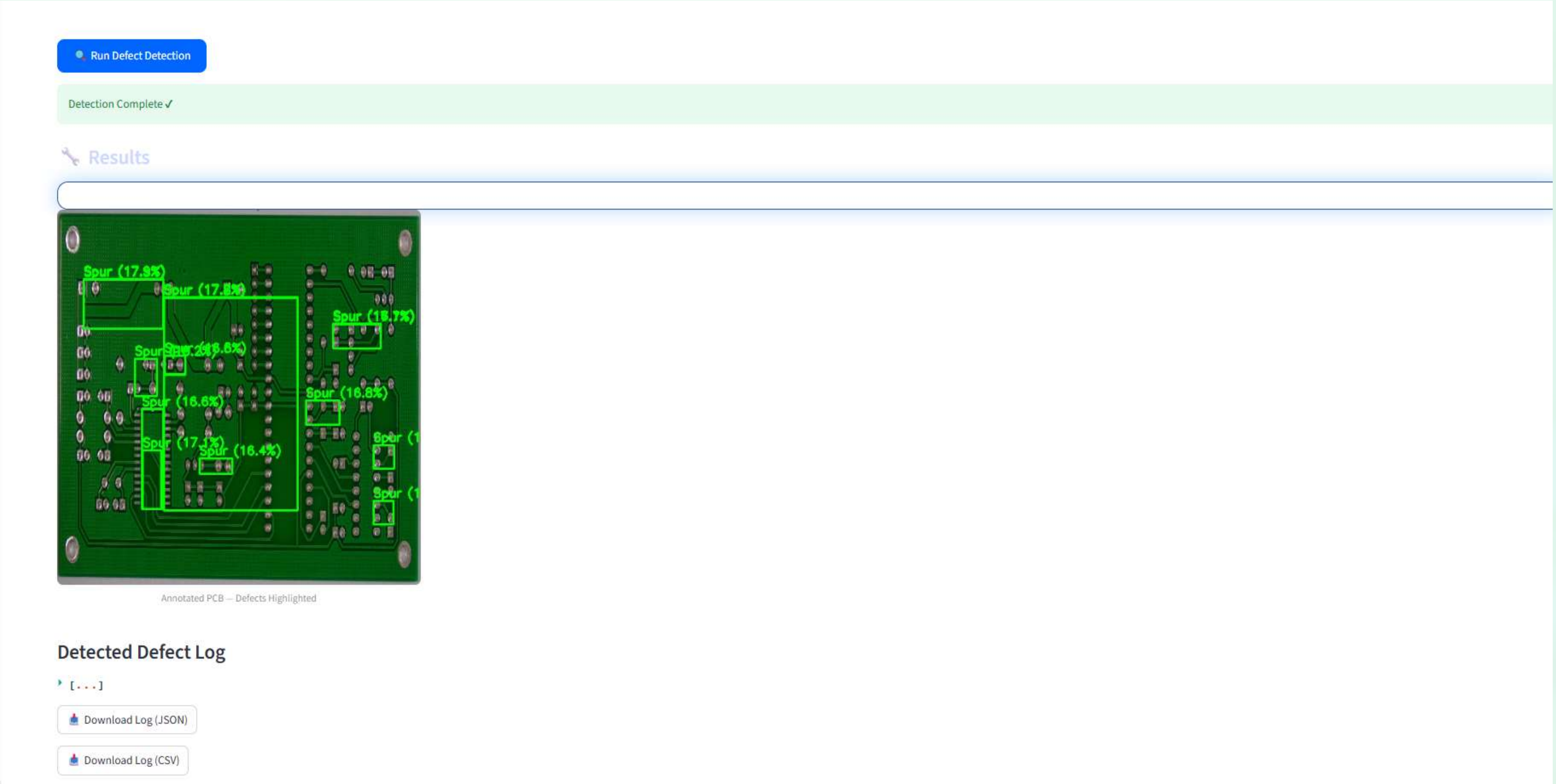
Select the defect you want to detect:

Spur

Detection Complete ✓

Results

Result :-Updated Result



Detection Complete ✓

Results

Annotated PCB — Defects Highlighted

Detected Defect Log

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