

BoardVision: Real-Time Motherboard Defect Detection using YOLOv7 and Faster R-CNN

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Motivation

Manual inspection of motherboard defects is time-consuming, inconsistent, and expensive. While deep learning offers promising solutions, most research in this area either lacks real-time usability or is focused on high-end industrial applications.

BoardVision addresses this gap by providing a lightweight, reproducible system for real-time defect detection using YOLOv7 and Faster R-CNN, packaged within a user-friendly GUI. The system was designed with educational and experimental deployment in mind, enabling accessible testing across video, image, and live webcam inputs.

Dataset

MiracleFactory Motherboard Defect Dataset

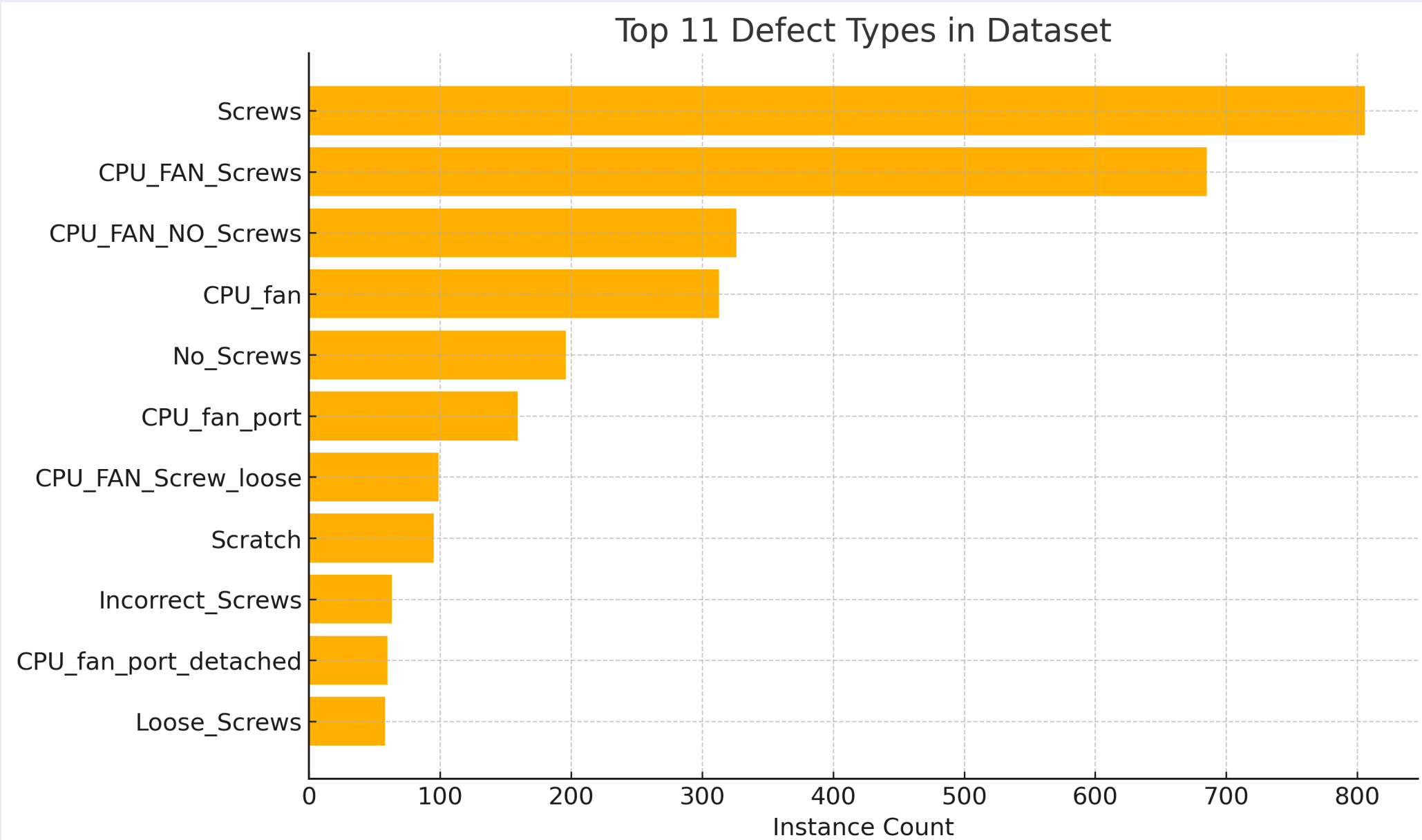
- 389 high-res images
- 2860 labeled defects
- 11 defect classes (e.g., scratches, bent pins, missing capacitors)

Class Imbalance:

- Screws*: 806 instances
- Loose Screws*: 58 instances

Burn Class (Test Only):

- 20 manually annotated images
- Used for out-of-distribution evaluation



Training Configuration

YOLOv7:

- Image size: 640×640
- Epochs: 50, Batch size: 16
- Optimizer: SGD, LR = 0.01
- Data augmentation: HSV jitter, flipping

Faster R-CNN:

- Backbone: ResNet-50 FPN (pretrained)
- Epochs: 50, Batch size: 8
- Optimizer: SGD, LR = 0.005
- Format: Pascal VOC-style annotations

Environment:

- GPU: NVIDIA RTX 1080 (8GB VRAM), 32GB System RAM
- PyTorch 2.0.0, CUDA 11.7

Real-time inference (14.2 FPS) with 74.2% mAP@0.5 — on a student-built pipeline.

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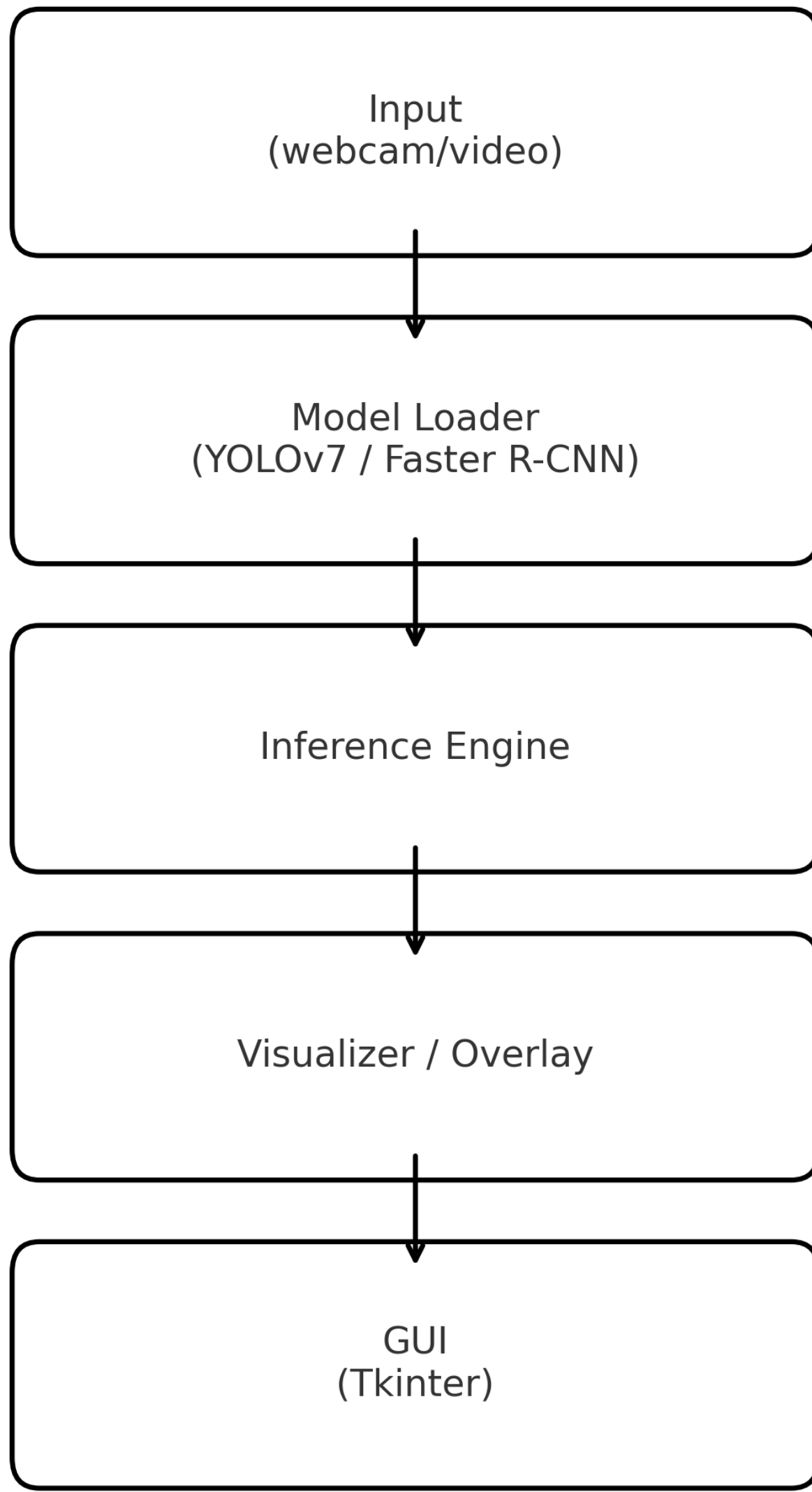
GitHub Page:



System Architecture

BoardVision was designed with modularity and real-time interaction in mind. The pipeline includes:

- Model Loader:** Loads YOLOv7 or Faster R-CNN at runtime
- Inference Engine:** Handles frame preprocessing, prediction, and device selection (CPU/GPU)
- Visualizer:** Overlays bounding boxes and confidence scores on frames
- GUI Interface:** Built with Tkinter; supports webcam, image, and video input



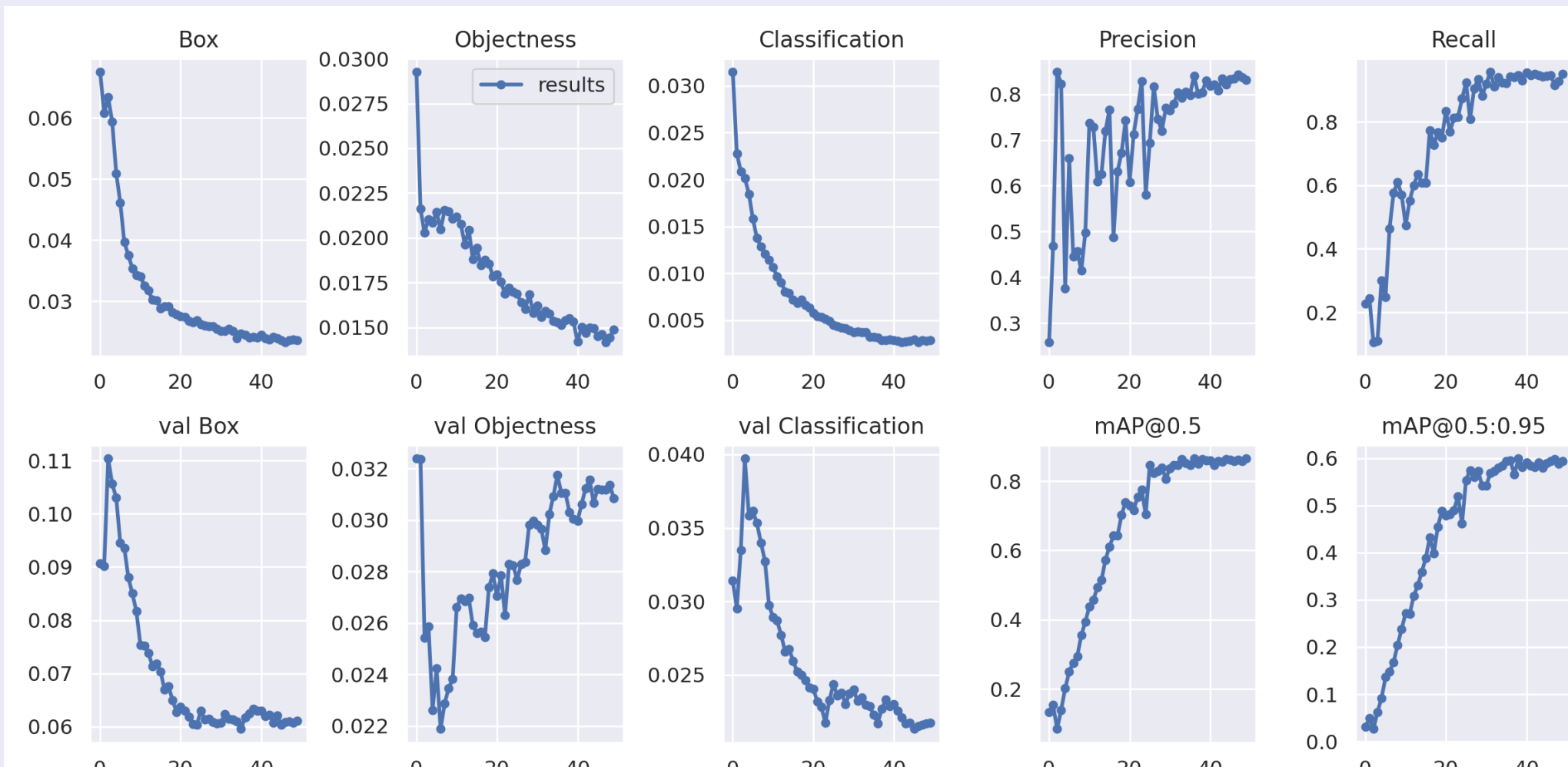
BoardVision pipeline overview

Evaluation Results

Per-Class F1 Comparison:

Class	YOLOv7	Faster R-CNN
Screws	0.80	0.72
Missing Capacitor	0.78	0.69
Scratch	0.77	0.62
Crack	0.72	0.59
Loose Screws	0.68	0.73
Bent Pin	0.75	0.71
Broken Pin	0.63	0.72
Missing IC	0.60	0.61
Short Circuit	0.70	0.73
Mean F1	0.71	0.68

YOLOv7 Training Trends



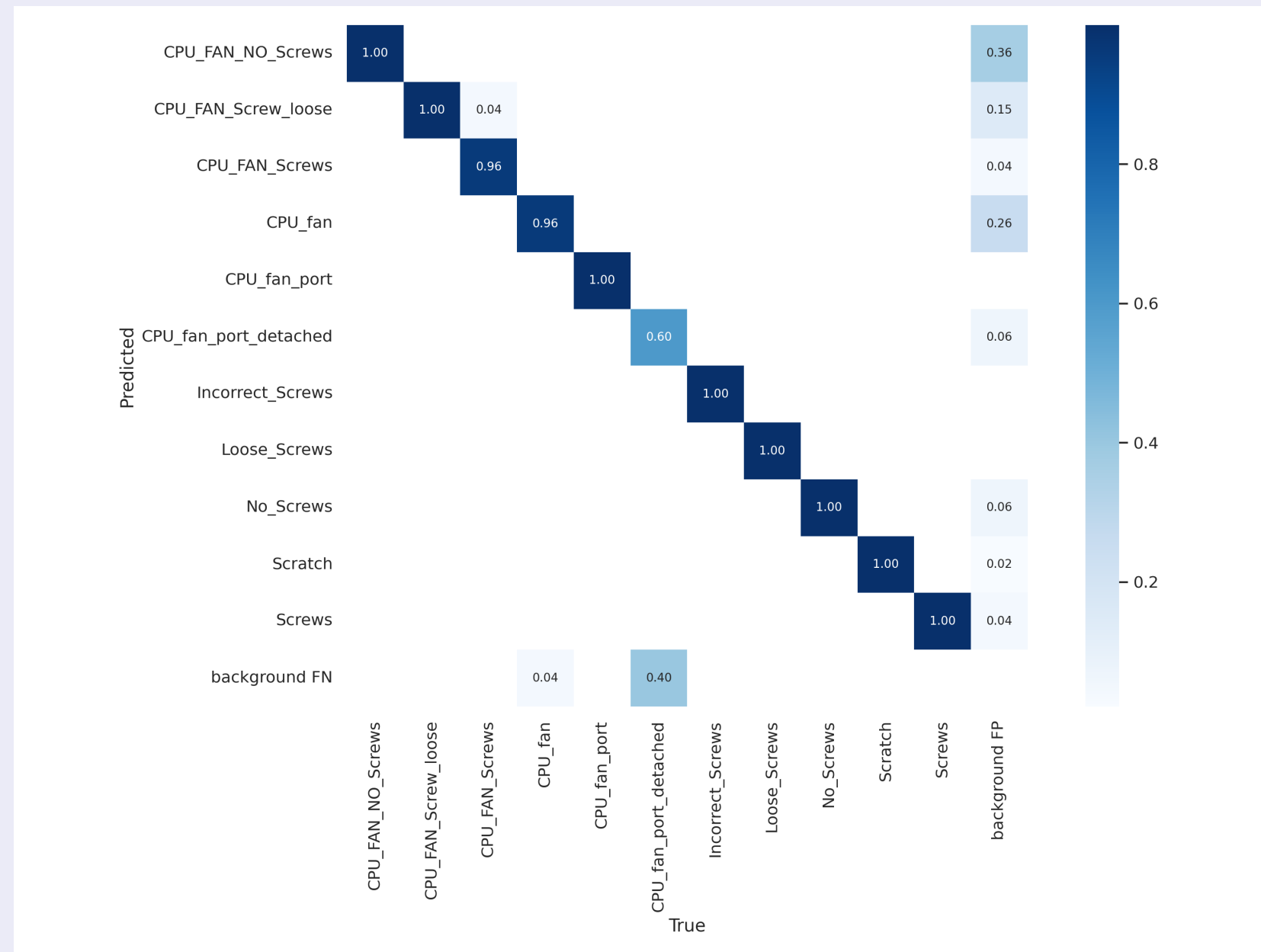
Performance Summary:

- YOLOv7:** 14.2 FPS, mAP@0.5 = 74.2%
- Faster R-CNN:** 8.3 FPS, mAP@0.5 = 69.4%, AR@100 = 81.3%

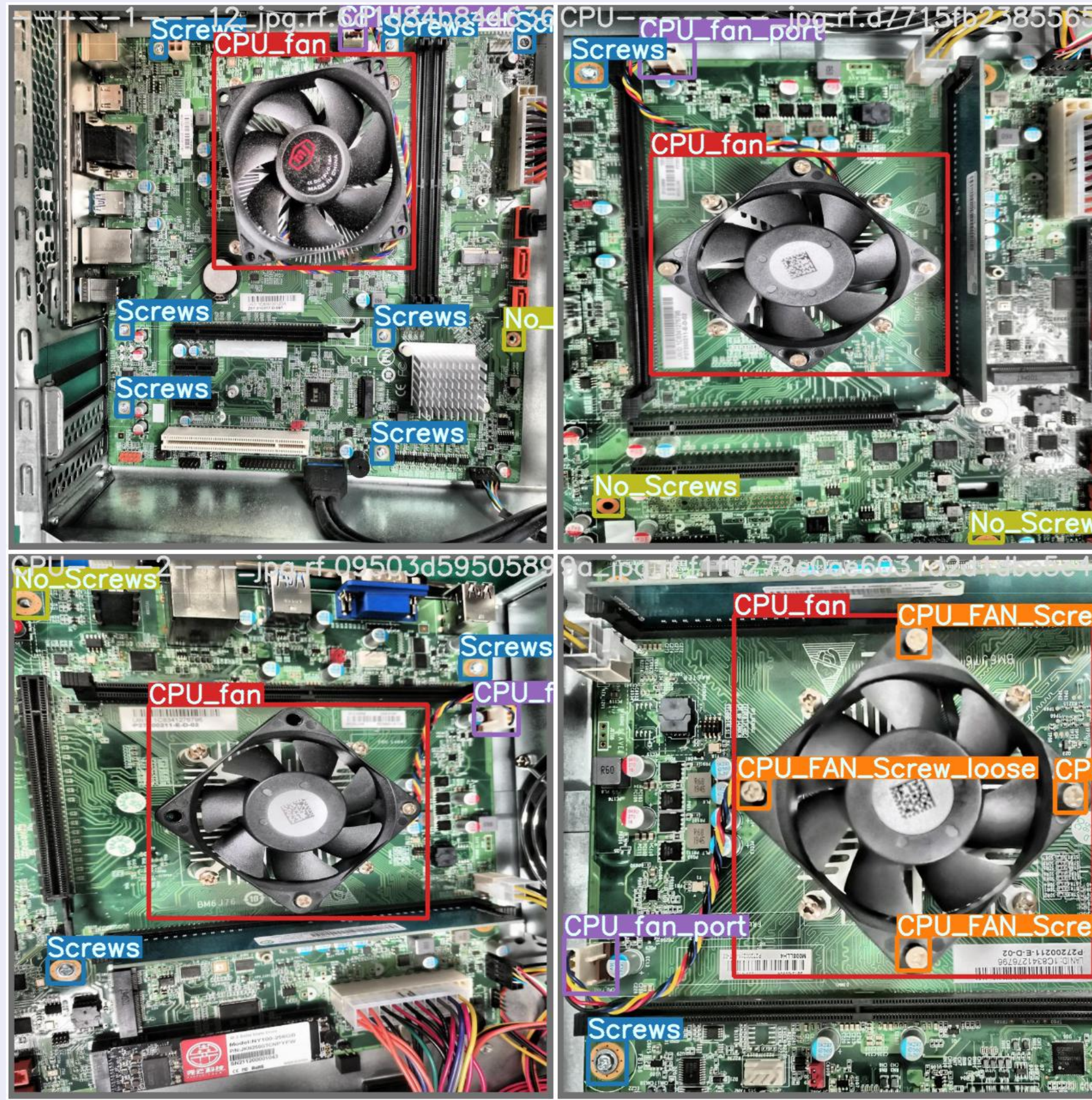
Key Observations:

- Common classes like Screws, CPU_fan are detected with high precision.
- Overlap exists between visually similar classes (e.g., Loose Screws vs. CPU_FAN_Screw_loose).
- Strong diagonal in the matrix = robust class separation.

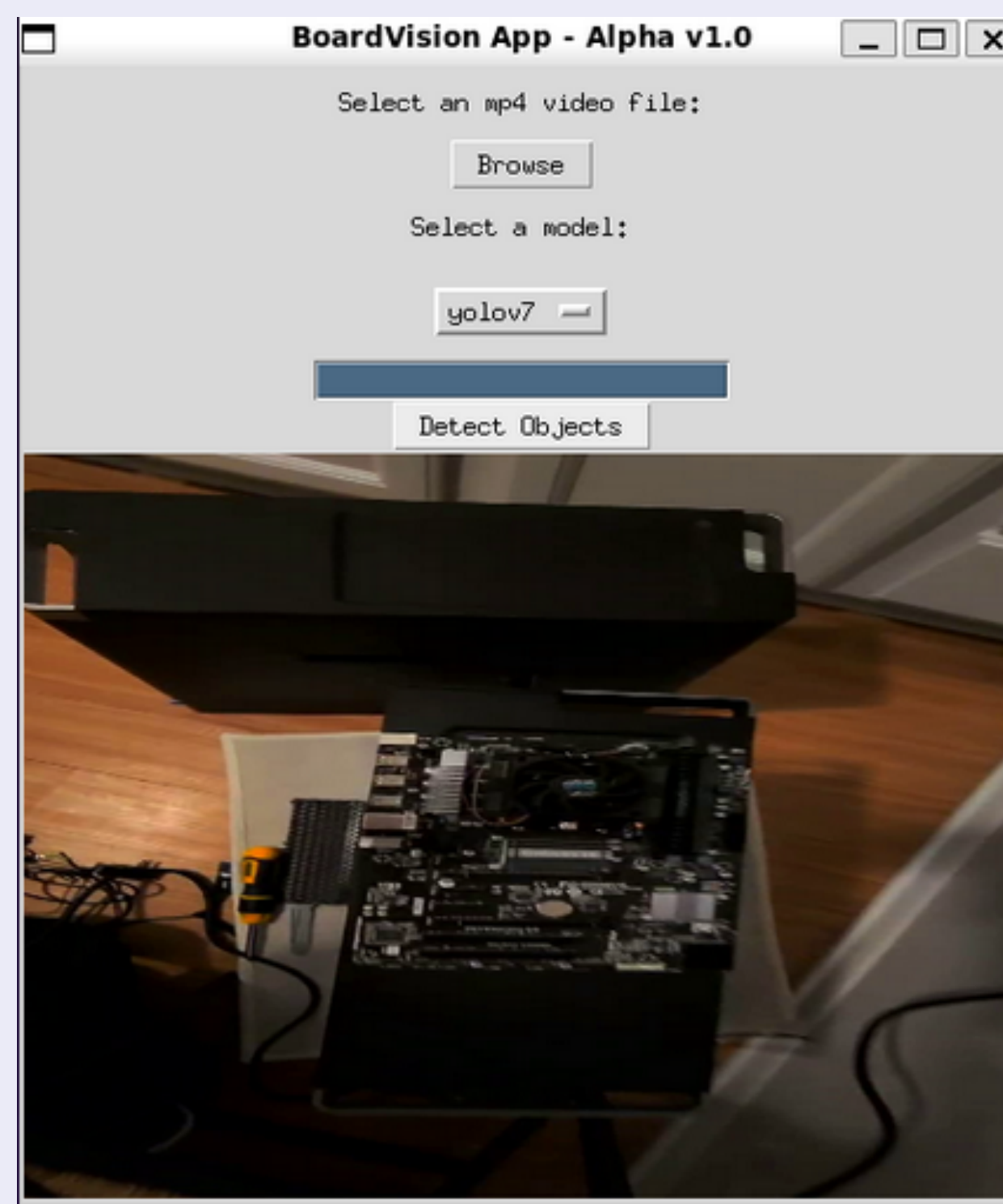
YOLOv7 Confusion Matrix



Detections on Motherboards



BoardVision GUI



- Developed using Tkinter (Python GUI)
- Supports model switching, live feed, and batch inference
- Displays bounding boxes with confidence scores in real time

Lessons and Future Work

- YOLOv7 offers real-time speed but may miss rare defect types
- Faster R-CNN performs better on imbalanced data, with lower speed
- GUI provides an accessible platform for testing and demonstration
- Future plans: ensemble switching, burn-class training, export features, deploy