Anomaly Detection in Printed Circuit Boards (PCBs) Using Deep Learning

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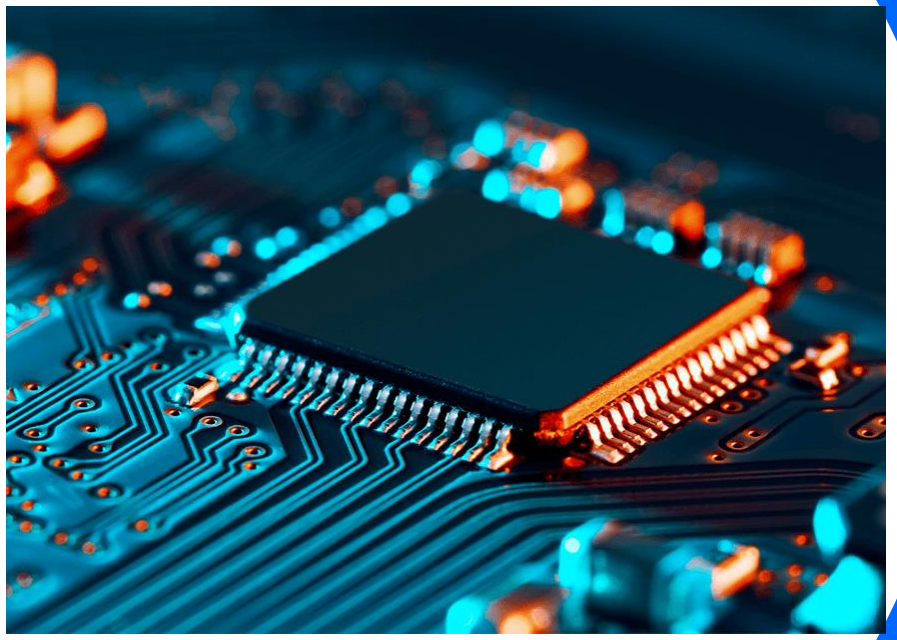
What is a PCB?

PCB (Printed Circuit Board) is a flat board with conductive pathways that connect electronic components.

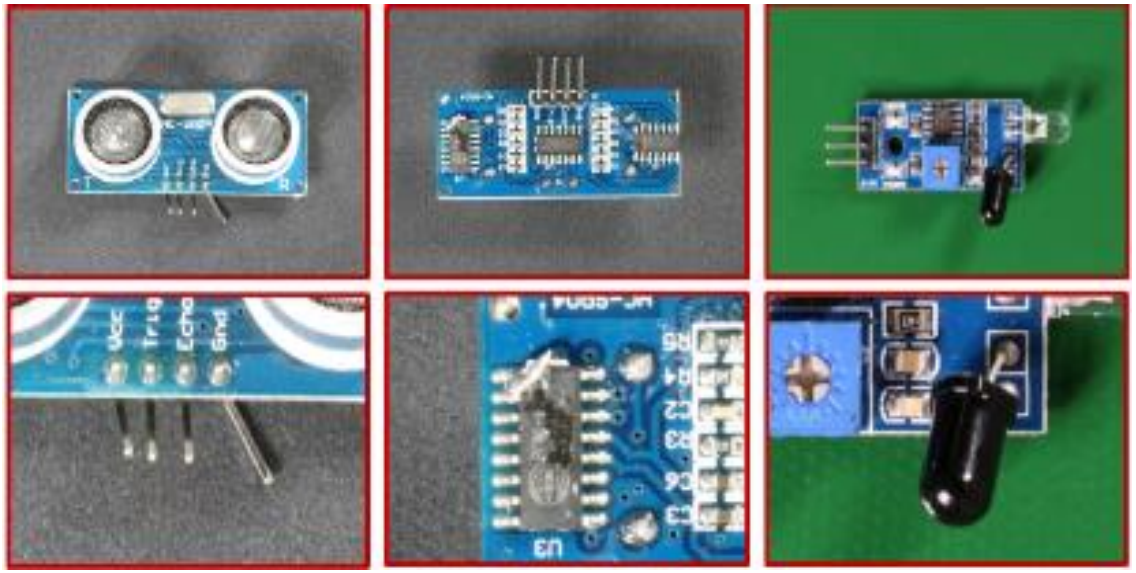
Importance:
Crucial in electronic devices for structurally supporting components and facilitating the flow of electrical signals.

Mass Production:
Facilitates cost-effective mass production of electronic devices through standardized assembly methods.



Common Anomalies in PCBs

- Soldering Issues
- Component Placement Errors
- Trace Defects
- Short Circuits
- Insufficient Insulation
- Corrosion and Contamination



Literature Review

Paper [1] - Arian et al. (2023)

- Introduces a novel reconstruction-based approach using diffusion models.

Paper [2] - Jaehyeok et al. (2023)

- Employs anomaly detection with normal samples, leveraging position data and a refinement network with synthetic abnormal images to reduce false negatives.

Paper [3] - Diulhio et al. (2023)

- Introduces a precise PCB anomaly detection using a convolutional auto-encoder and a novel loss function.

Literature Review

Paper [4] - Jeong et al. (2023)

- Introduces WinCLIP for anomaly detection with few labeled examples, using a compositional ensemble method and proposing a few-normal-shot extension for improved performance using CLIP.

Paper [5] - Lim et al. (2023)

- Proposes a PCB defect detection model with a multi-scale feature pyramid network.

Paper [6] - Ristea et al. (2022)

- Introduces SSPCAB as a generic building block for anomaly detection, utilizing self-supervised learning, predictive convolutional attentive blocks, and a channel attention module.

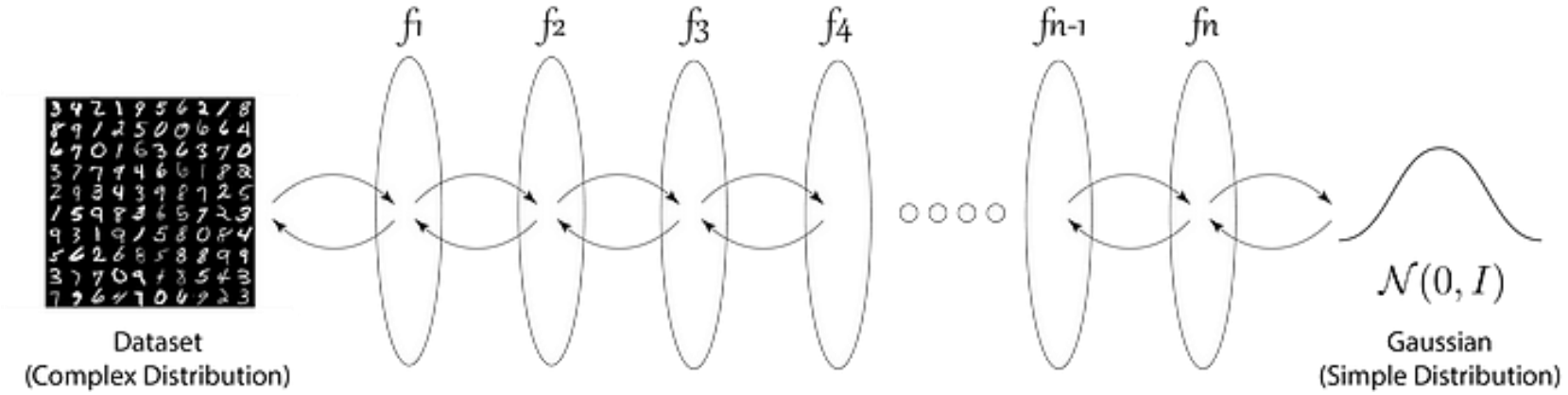
Dataset

- **Dataset Name:** VisA
- **Number of Subsets:** 12, corresponding to 12 different objects.
- **Total Images:** 10,821
- **Normal Samples:** 9,621
- **Anomalous Samples:** 1,200
- **PCB Subsets:** Four subsets represent different types of PCBs with complex structures containing transistors, capacitors, chips, etc.
- Anomalous samples include various flaws:
  - Surface defects such as Corrosion, Contamination, or cracks.
  - Structural defects like misplacement or missing parts.

Methodology

Normalizing Flows

- Normalizing flows is a series of simple functions which are invertible, or the analytical inverse of the function can be calculated.



Model Architecture

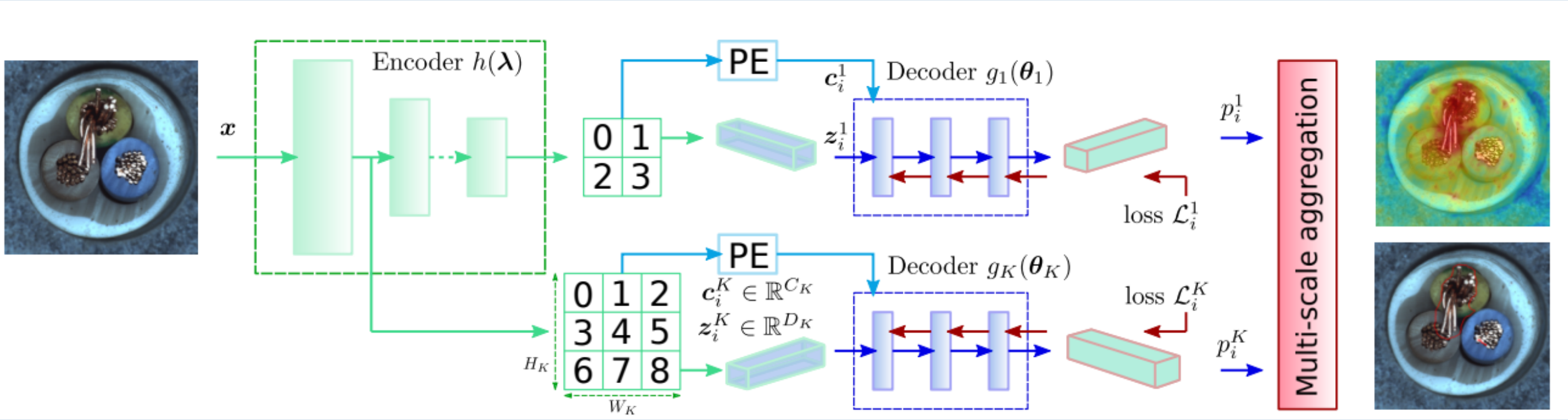
CFLOW Encoder (Feature Extraction):

- Implements a multiscale feature pyramid pooling scheme using a WideResNet-50 pretrained on ImageNet for discriminatively-trained CNN feature extraction.

CFLOW Decoders (Likelihood Estimation):

- Adopts a general normalizing flow framework for log-likelihood estimation of feature vectors.
- Introduces a conditional flow framework with spatial priors, using K independent decoder models for multi-scale feature pyramid pooling.

Model Architecture



Results

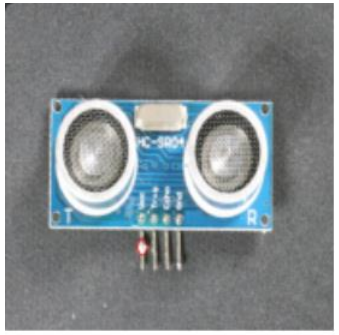
Results

	Cflow[7]		DREAM[8]	CFA[9]	SPD[10]
Class Name	Segmentation AUC	Detection AUC	Detection AUC	Detection AUC	Detection AUC
PCB1	0.9937	0.9551	54.8	90.0	92.7
PCB2	0.9658	0.9252	77.8	75.6	87.9
PCB3	0.9682	0.9323	94.5	94.9	85.4
PCB4	0.9700	0.9753	93.4	97.3	99.1

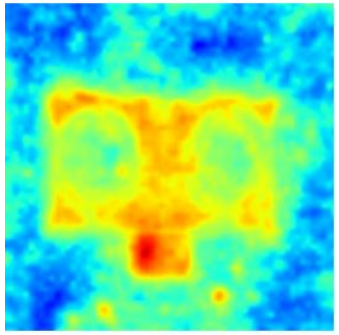
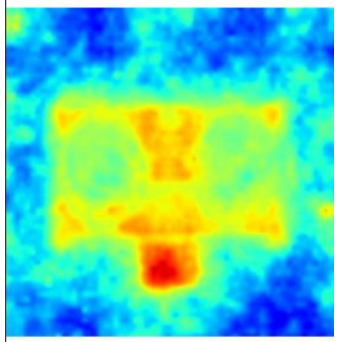
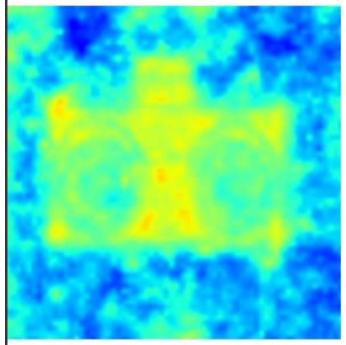
Results

- PCB1

Ground Truth



Heatmap

Predicted



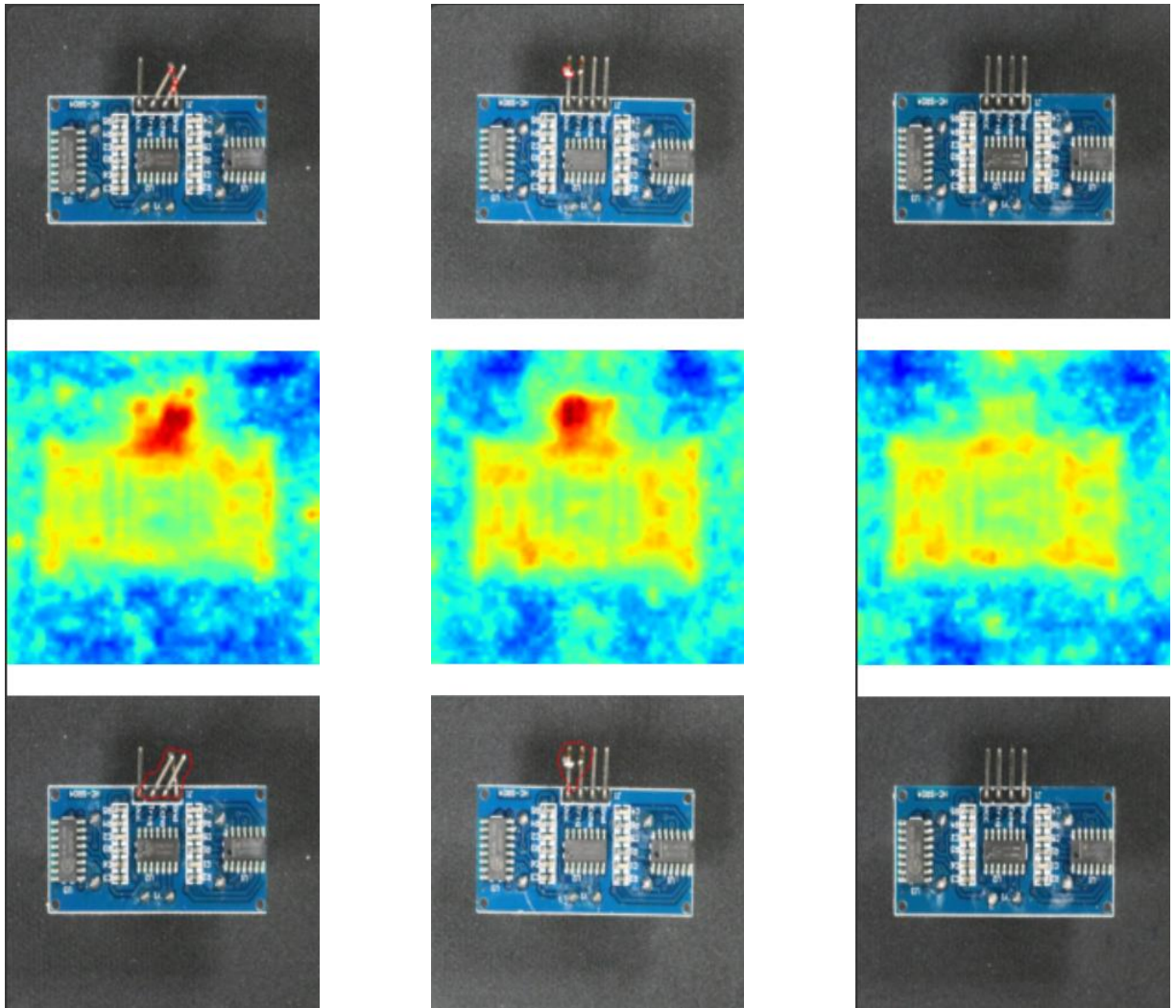
Results

- PCB2

Ground Truth

Heatmap

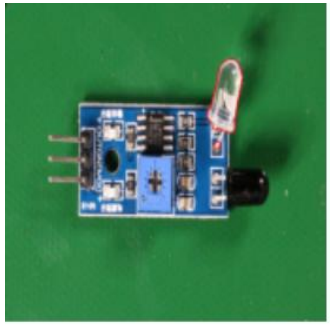
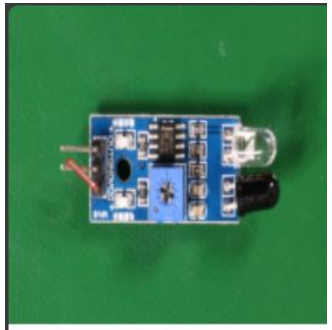
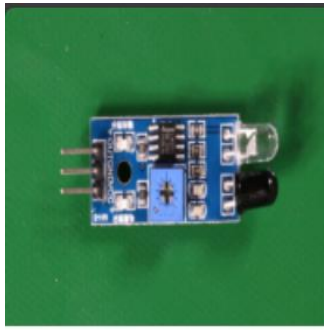
Predicted



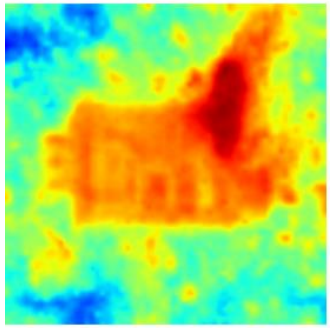
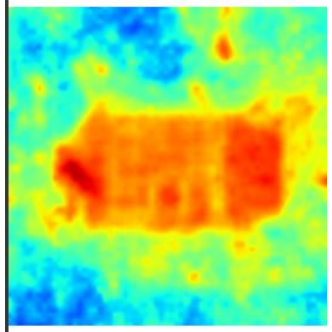
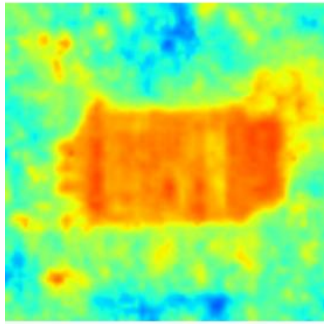
Results

- PCB3

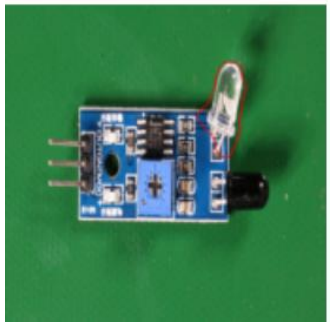
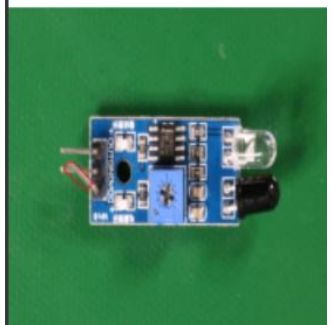
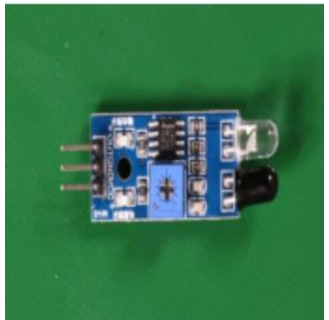
Ground Truth

Heatmap

Predicted

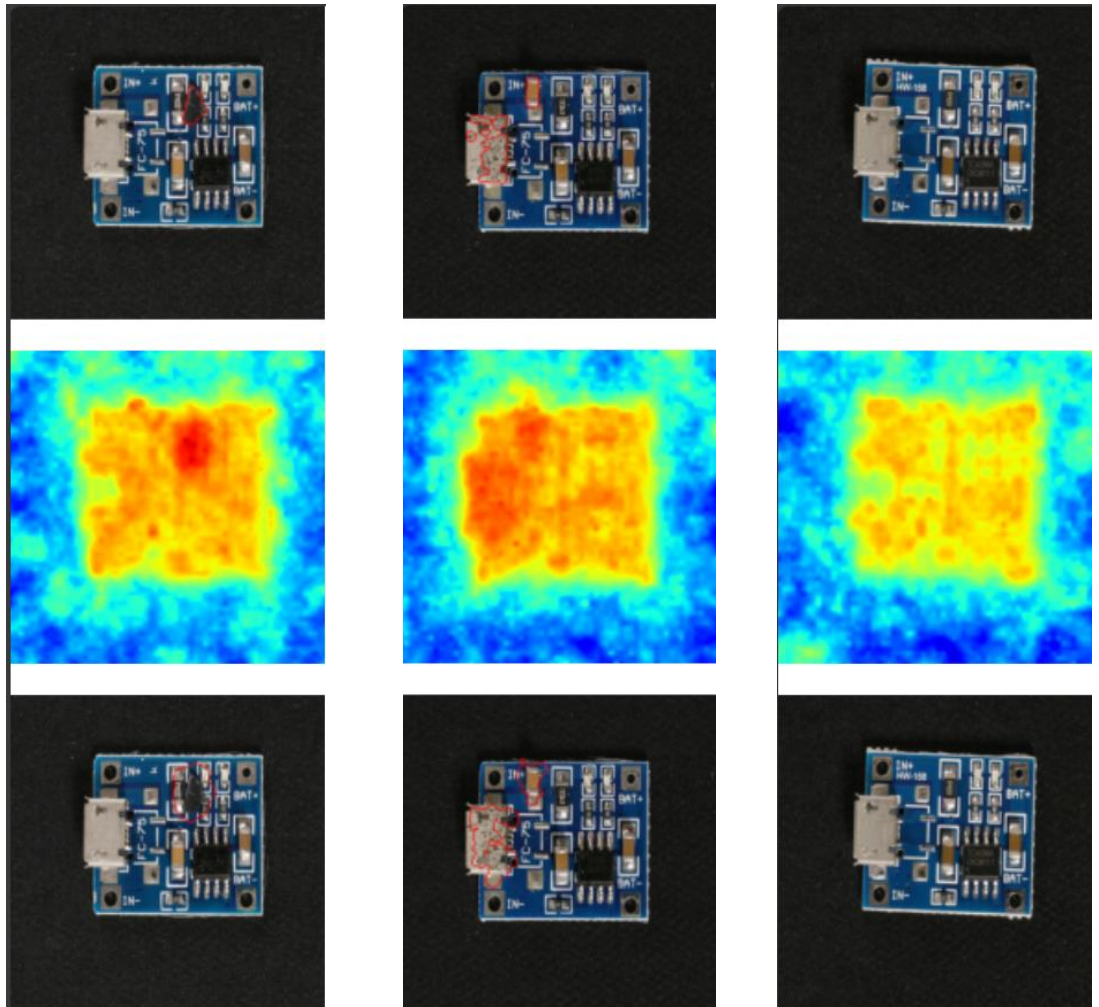
Results

- PCB4

Ground Truth

Heatmap

Predicted



Thank you

References

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