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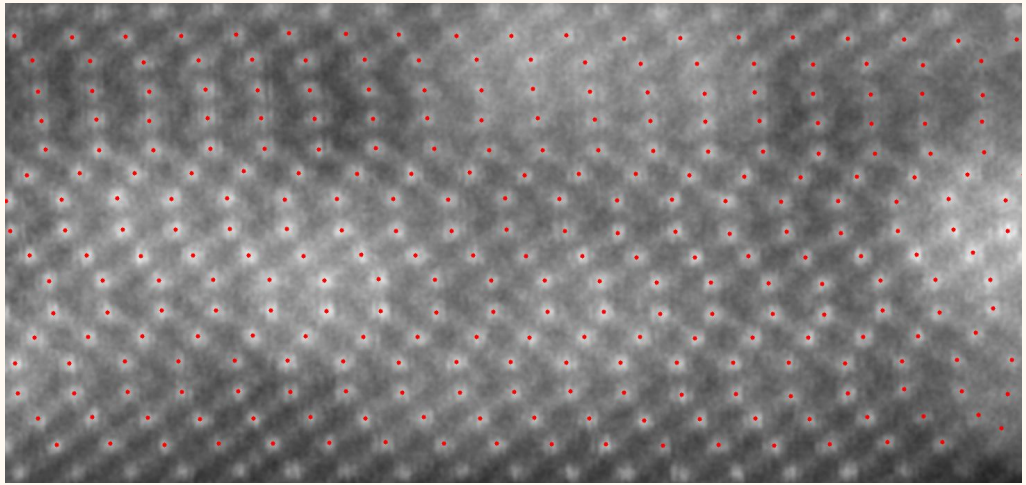
Computer Vision Mini-Projects Portfolio

A collection of experimental CV projects created as pet-projects. These are not core work cases but examples that can be quickly and visually demonstrated.

Goal

Develop a script to accurately locate atomic positions in electron microscopy images of varying complexity.



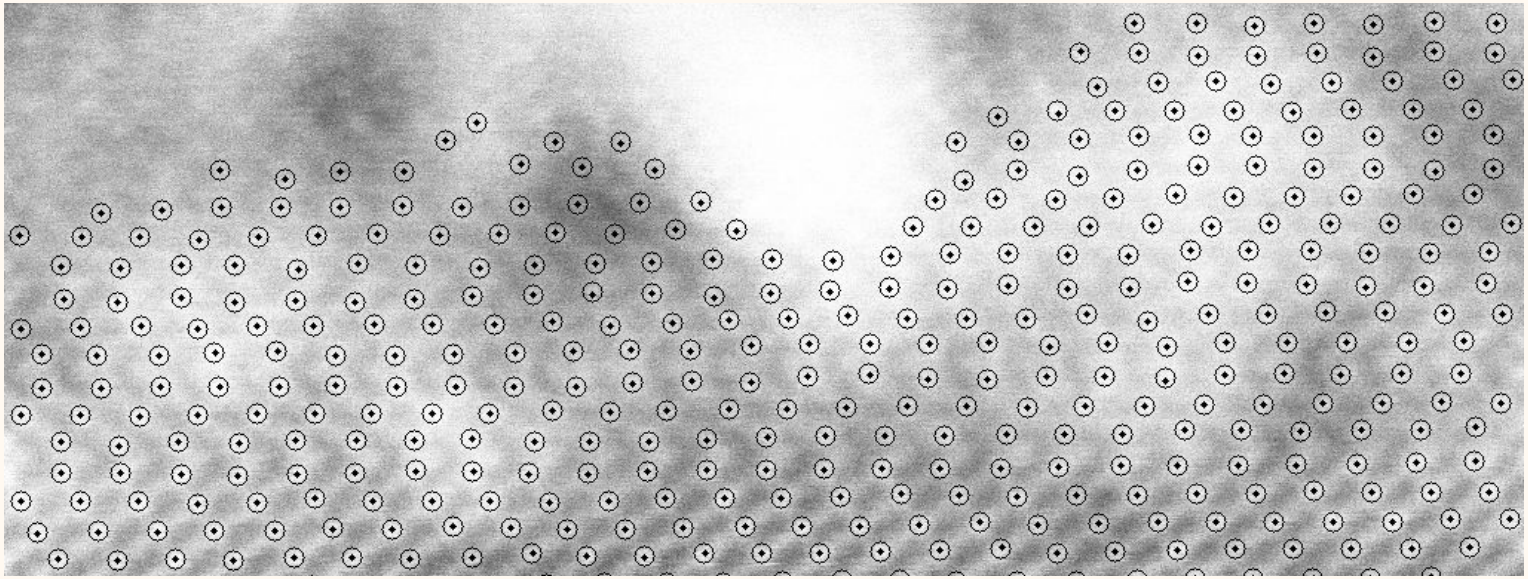
Process

- Preprocess images to remove background noise.
- Use **Difference of Gaussians (DoG)** to detect approximate atom positions.
- Filter detections using **average inter-atomic distance** to remove spurious objects.
- Refine positions via **Gaussian fitting** for sub-pixel accuracy.

Result

Achieved **high-precision atomic coordinates** across images with different levels of complexity.

Example of Challenging Atomic Position Detection

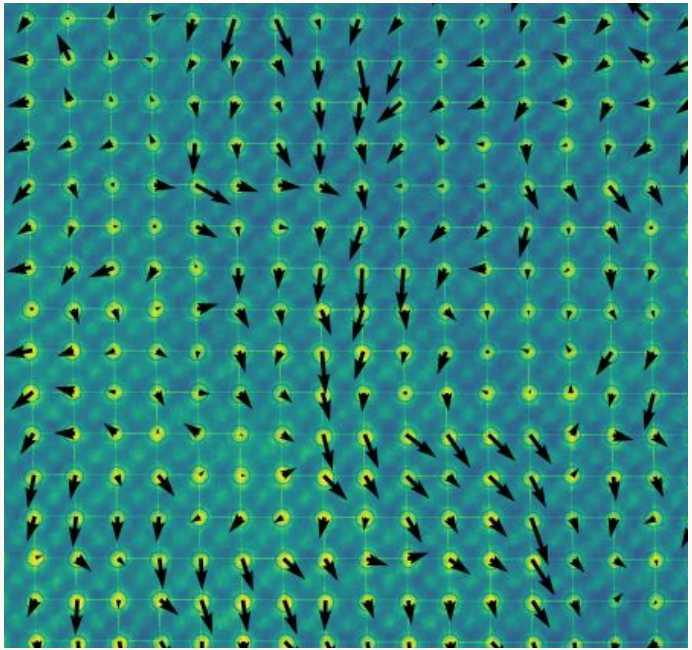


Dots: approximate atom positions detected by DoG.
Circles: refined positions after Gaussian fitting.

Demonstrates that the algorithm performs **robustly on low-contrast images with complex backgrounds**

Goal

Develop a script that **automatically determines atomic displacements** from ideal lattice positions in order to calculate the material's stress/strain tensor.



Process

- Detect atomic positions.
- Organize atoms into rows and columns; approximate them with straight lines.
- Estimate average unit cell size → construct theoretical lattice grid.
- For each atom, compute displacement as difference between **measured** and **ideal** positions.

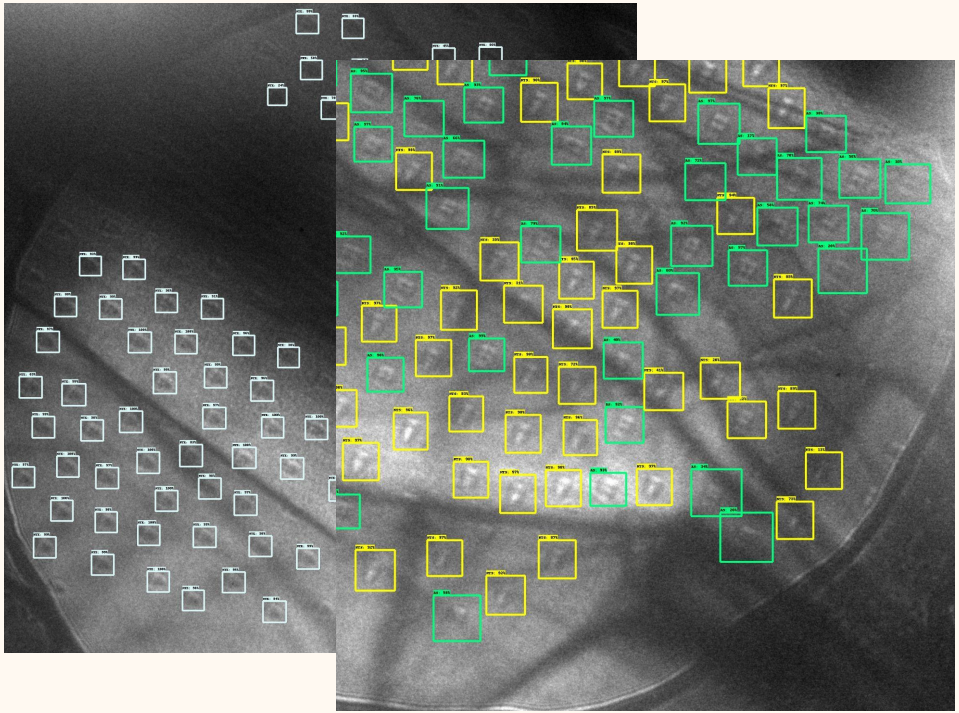
Result

Partners satisfied with the added research opportunity

Circles: actual atom positions. **Lines**: approximated lattice rows/columns. **Arrows**: direction & relative magnitude of atomic displacements

Goal

Automate the detection and classification of five custom object types in microscopy images, replacing manual labeling by students.



Process

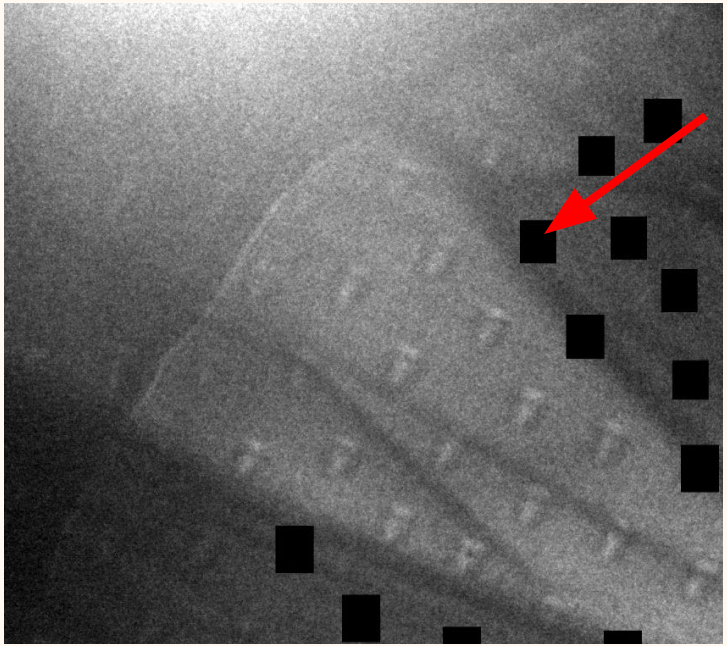
- Used transfer learning with a pre-trained model and fine-tuned it for five target classes.
- Implemented automated pipeline for object localization and classification.

Result

- Replaced slow and error-prone manual work by students with an automated script.
- Provided new datasets that led to scientific publications and expanded research opportunities

Goal

Improve model performance when training data contains images with only partially annotated objects.



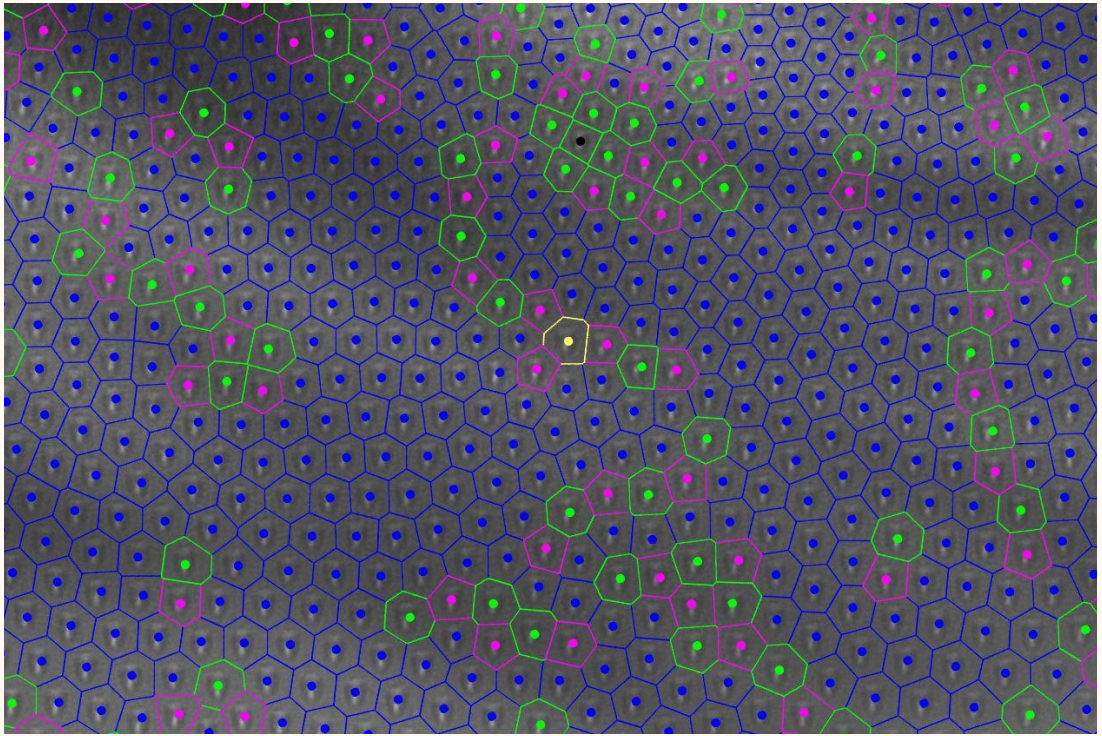
Process

- Wrote a preprocessing script to detect potential regions with unlabeled objects.
- Masked these regions with black rectangles so the model would ignore them during training.

Result

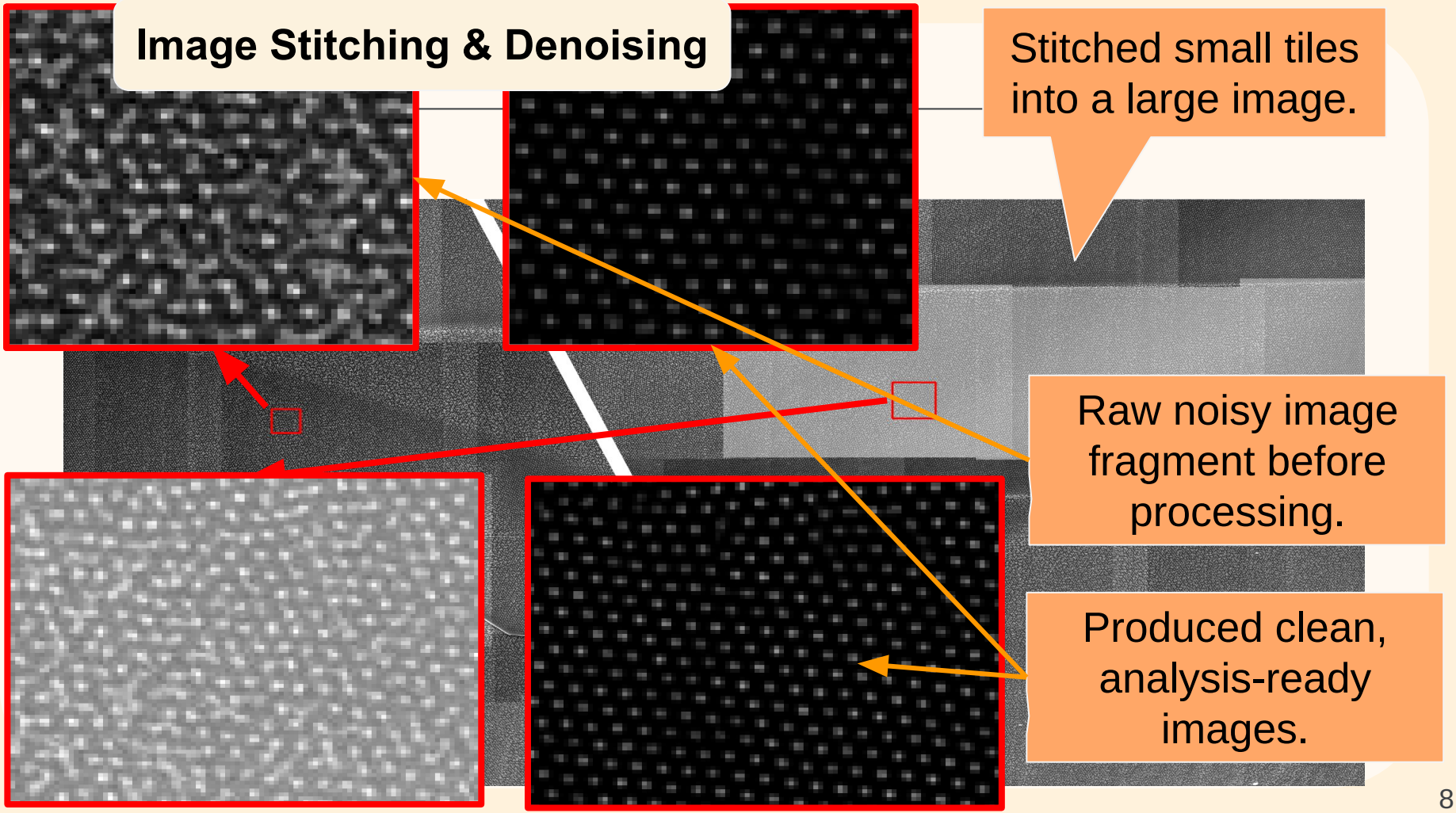
- Successfully eliminated the negative impact of unlabeled objects.
- Achieved robust object detection accuracy despite incomplete annotations.

Applying Model to Larger Images from Another Experiment



- Applied sliding window to detect objects in large experimental images.
- Stitched results and visualized nearest neighbors using Voronoi diagram (Blue = 6 neighbors (ideal), Green = 7, Pink = 5).
- Identified lattice defects and deviations.
- Enabled statistical analysis of material structure.

Image Stitching & Denoising

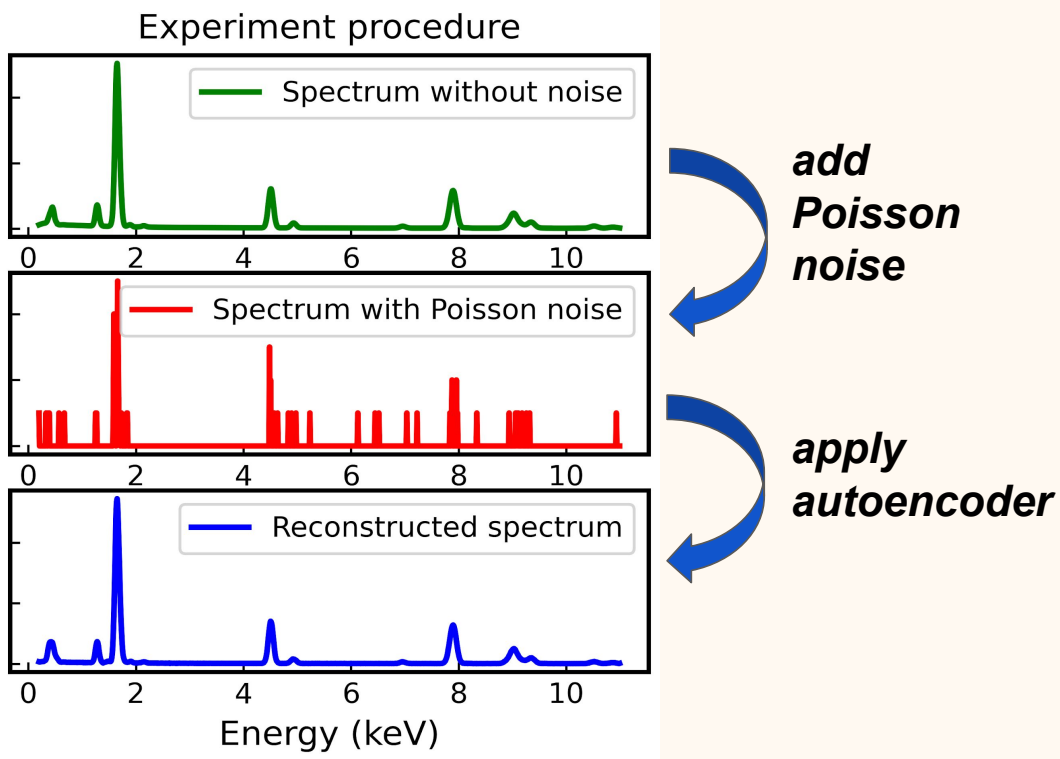


Stitched small tiles into a large image.

Raw noisy image fragment before processing.

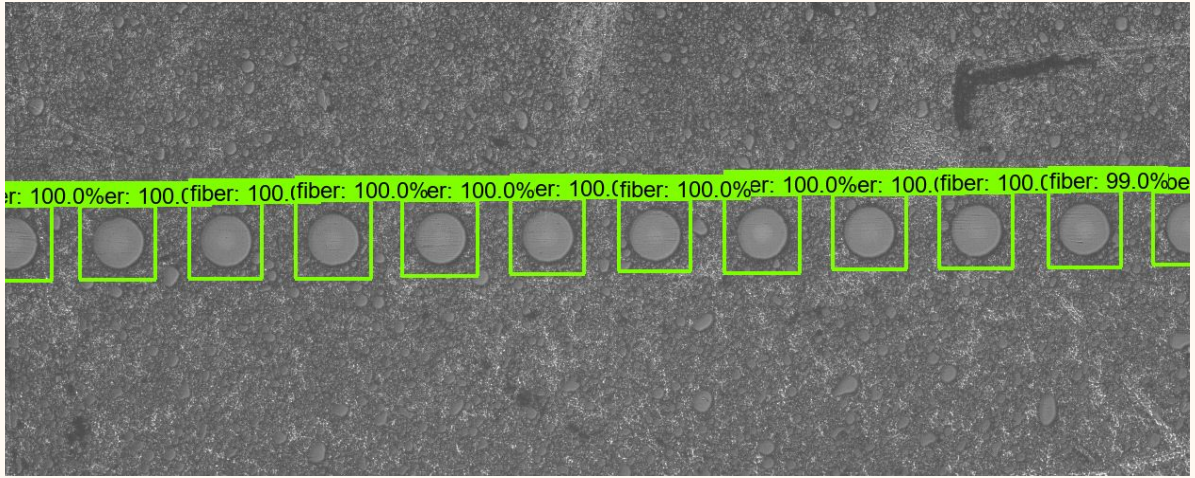
Produced clean, analysis-ready images.

Spectrum Denoising via Autoencoder



Goal

Rough detection of optical fibers on a connector to enable precise positioning and inspection of critical zones for cleanliness according to standards.



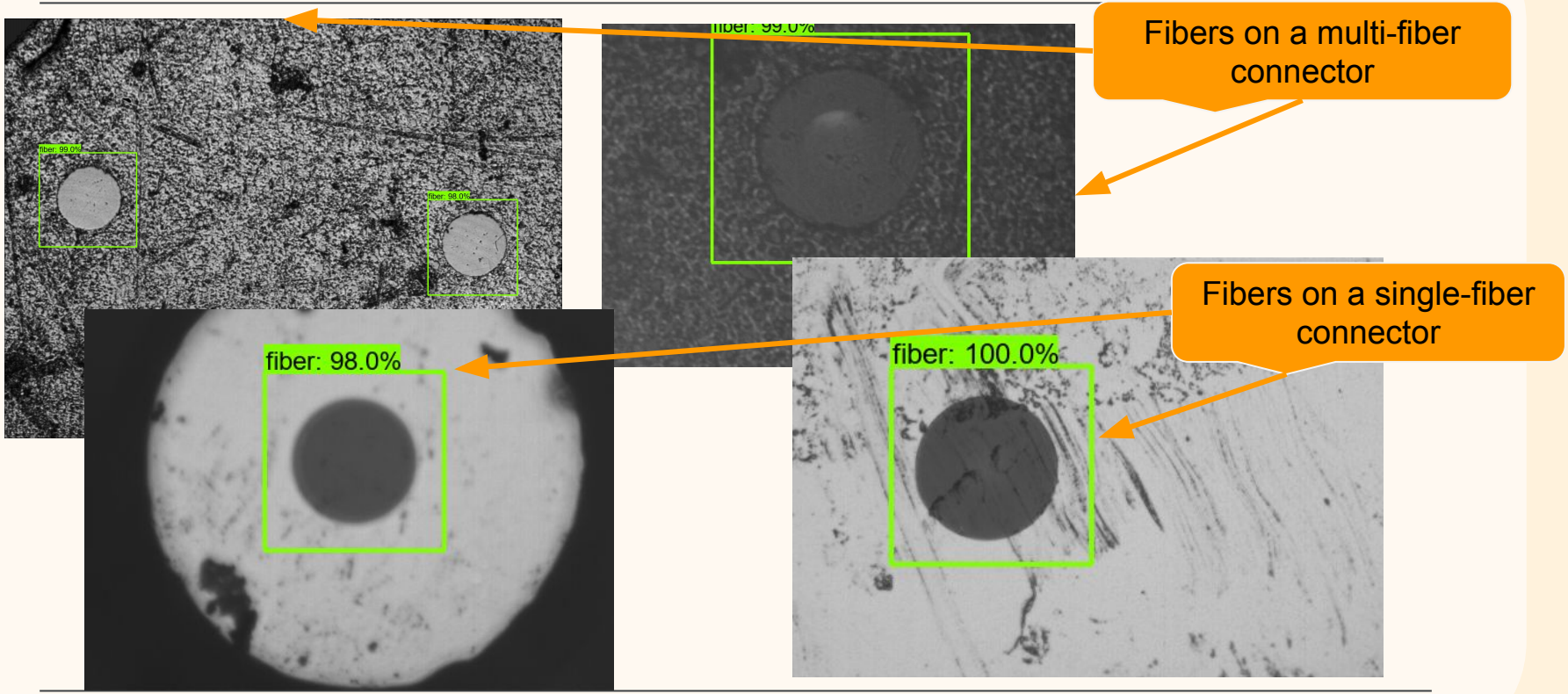
Process

- Started with a frozen pre-trained model.
- Fine-tuned for custom fiber detection.

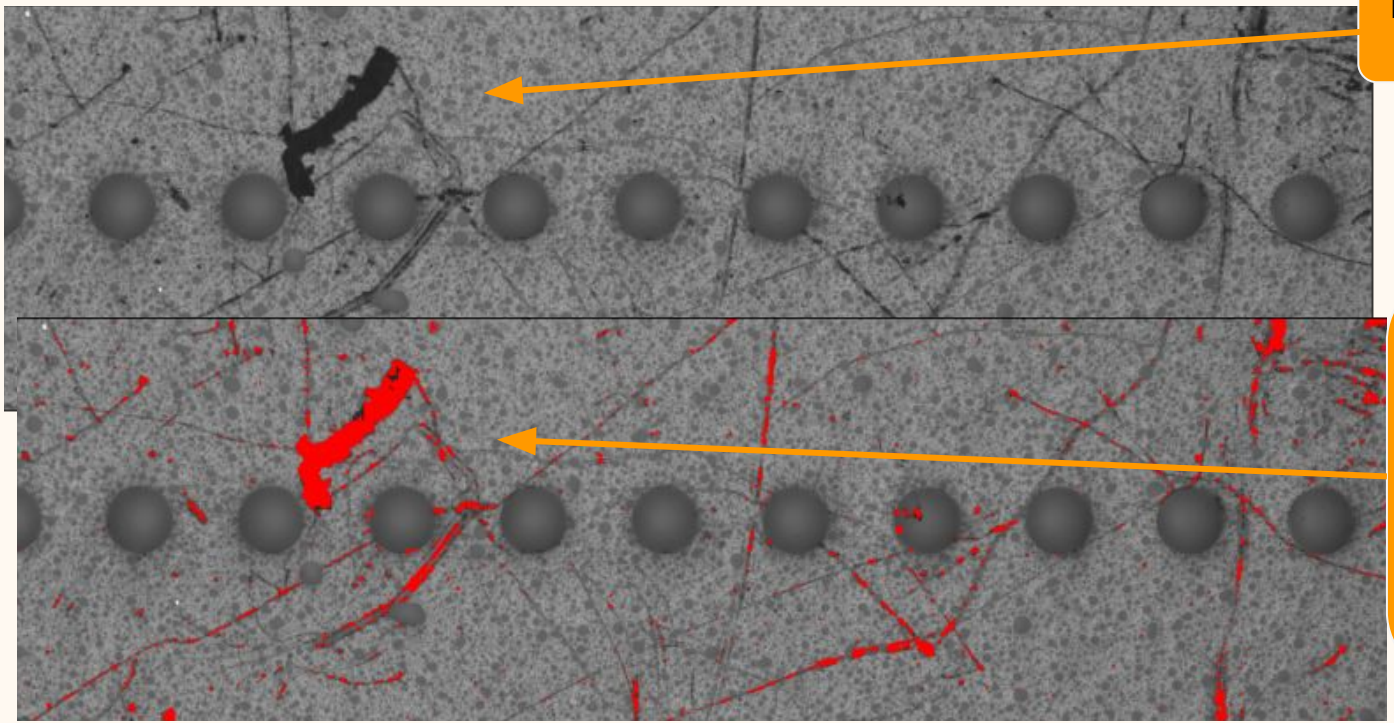
Result

- Successfully localized fibers on the connector.
- Provided a basis for automated analysis of fiber connector cleanliness.

Testing Object Detection Across Connector Variants



Contamination Detection on Multi-Fiber Connector



Fibers on a multi-fiber connector

Segmentation result: detected contamination using U-Net (trained on only 7 annotated images; method successfully used by clients for over 4 years)