SoftPatch: Unsupervised Anomaly Detection with Noisy Data

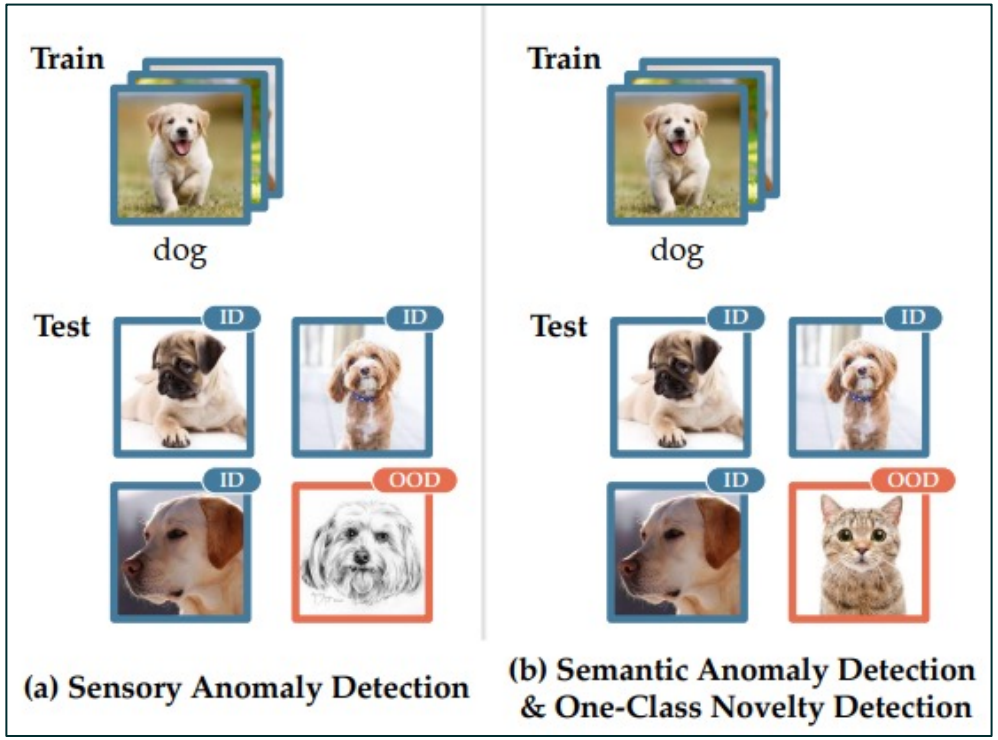
Xi Jiang, Jianlin Liu, Jinbao Wang, Qian Nie,

Kai Wu, Yong Liu, Chengjie Wang, Feng Zheng

The State of Visual Anomaly Detection

Semantic Anomaly Detection

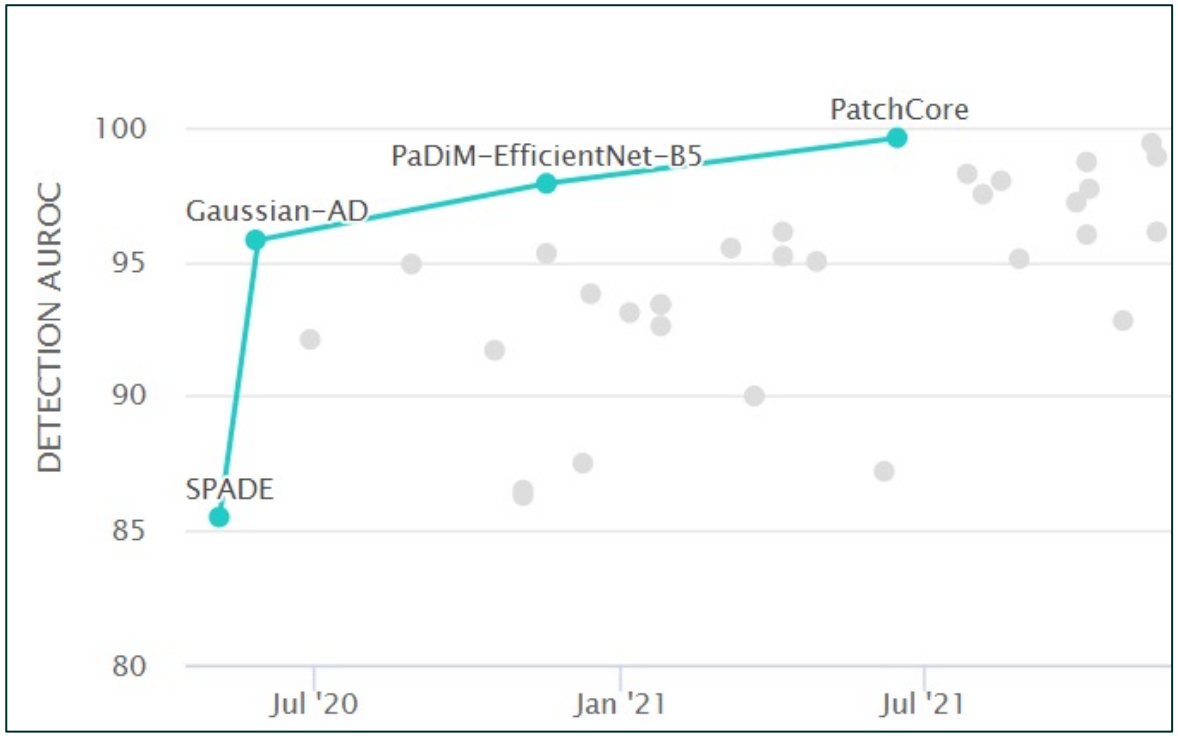
Sensory Anomaly Detection



Yang, Jingkang, et al. “Generalized out-of-distribution detection: A survey. ” ArXiv 2021

The State of Visual Sensory Anomaly Detection

Sensory Anomaly Detection

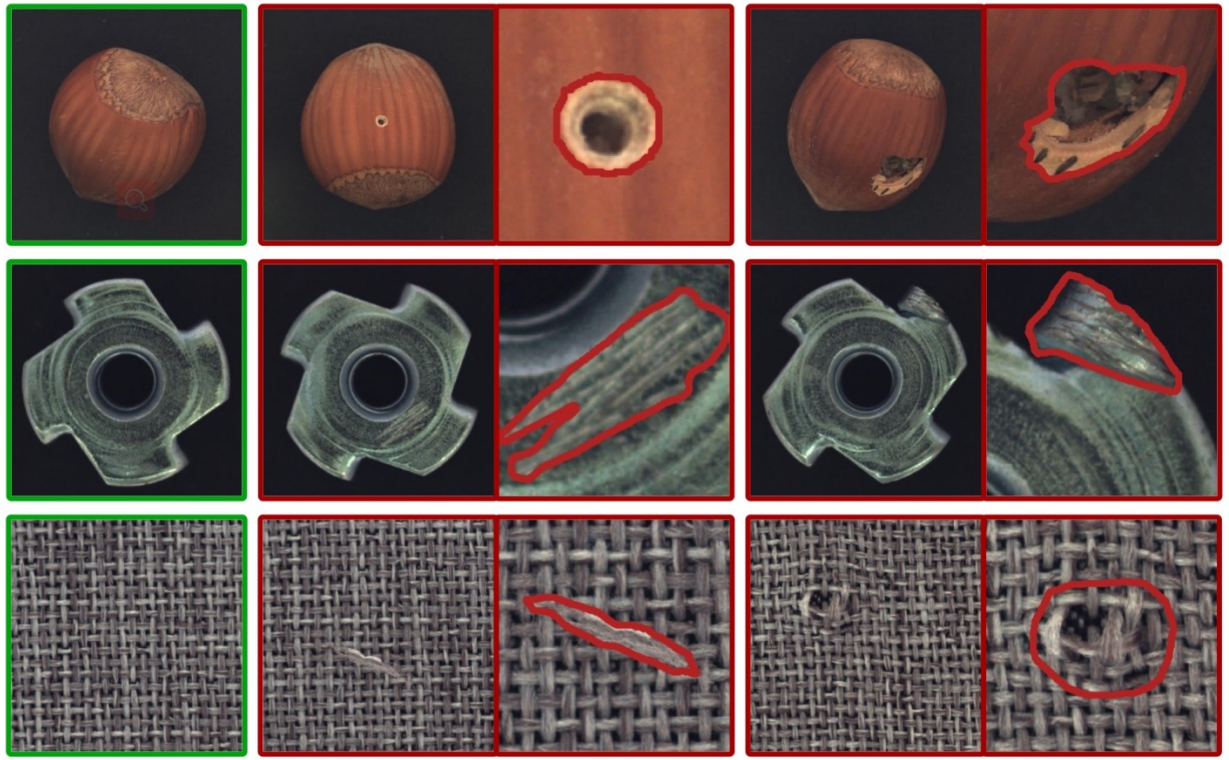


Source: https://paperswithcode.com/sota/anomaly-detection-on-mvtec-ad

The State of Visual Sensory Anomaly Detection

Sensory Anomaly Detection

Visual Inspection



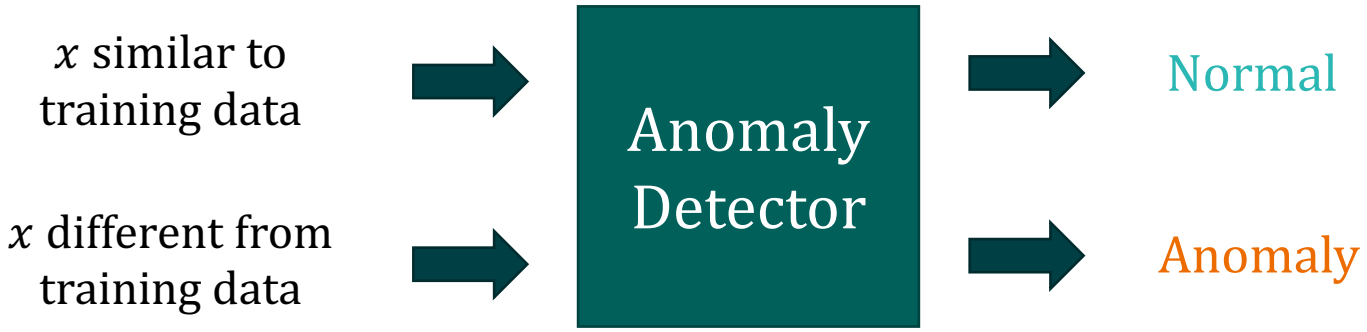
Both anomaly detection and localization

Bergmann, Paul, et al. "MVTec AD--A comprehensive real-world dataset for unsupervised anomaly detection." CVPR 2019.

The State of Visual Sensory Anomaly Detection

Rely on A Common Assumption:

All training samples are anomaly-free.

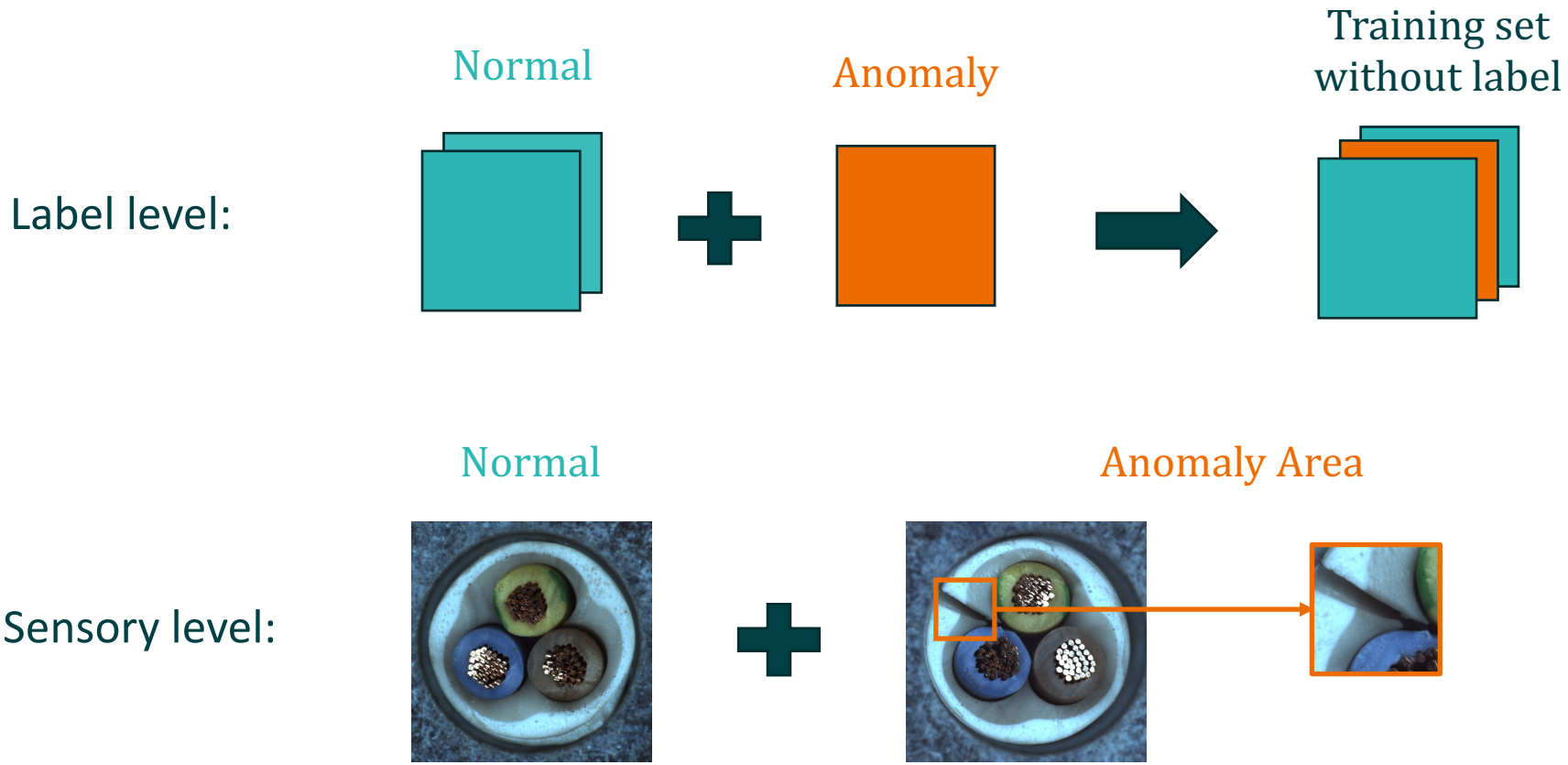


Difficult to apply to actual inspection when:

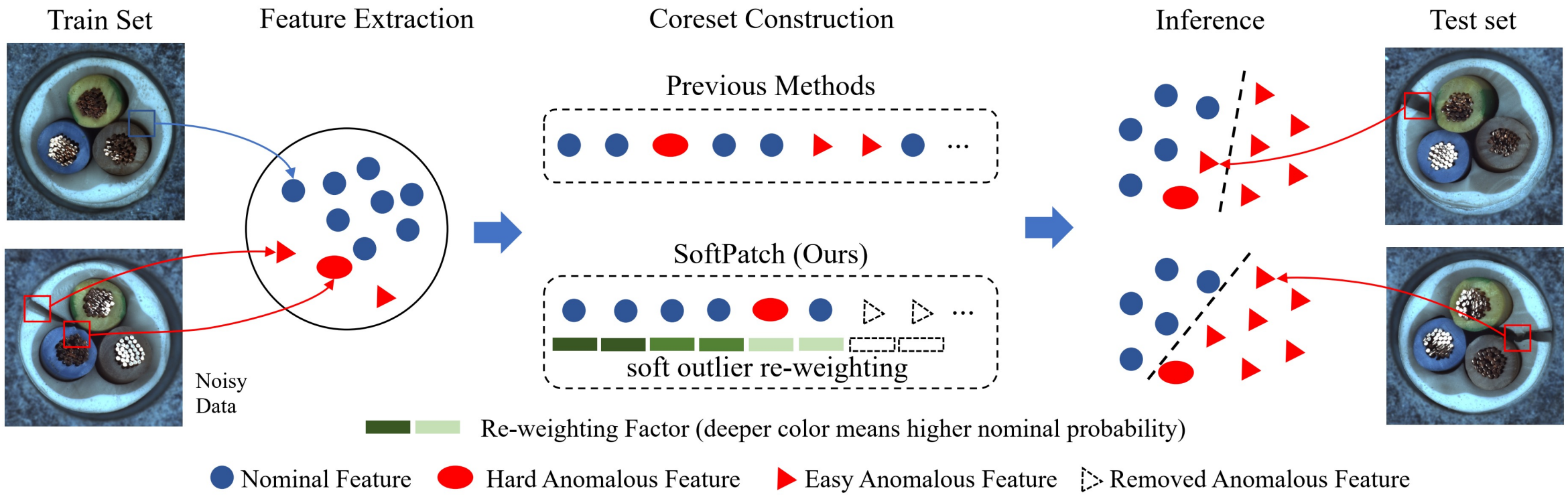
- Including noise from the inherent shift or human misjudgment
- Rapid deployment without enough time for data filtration

Sensory Anomaly Detection with Noisy Data

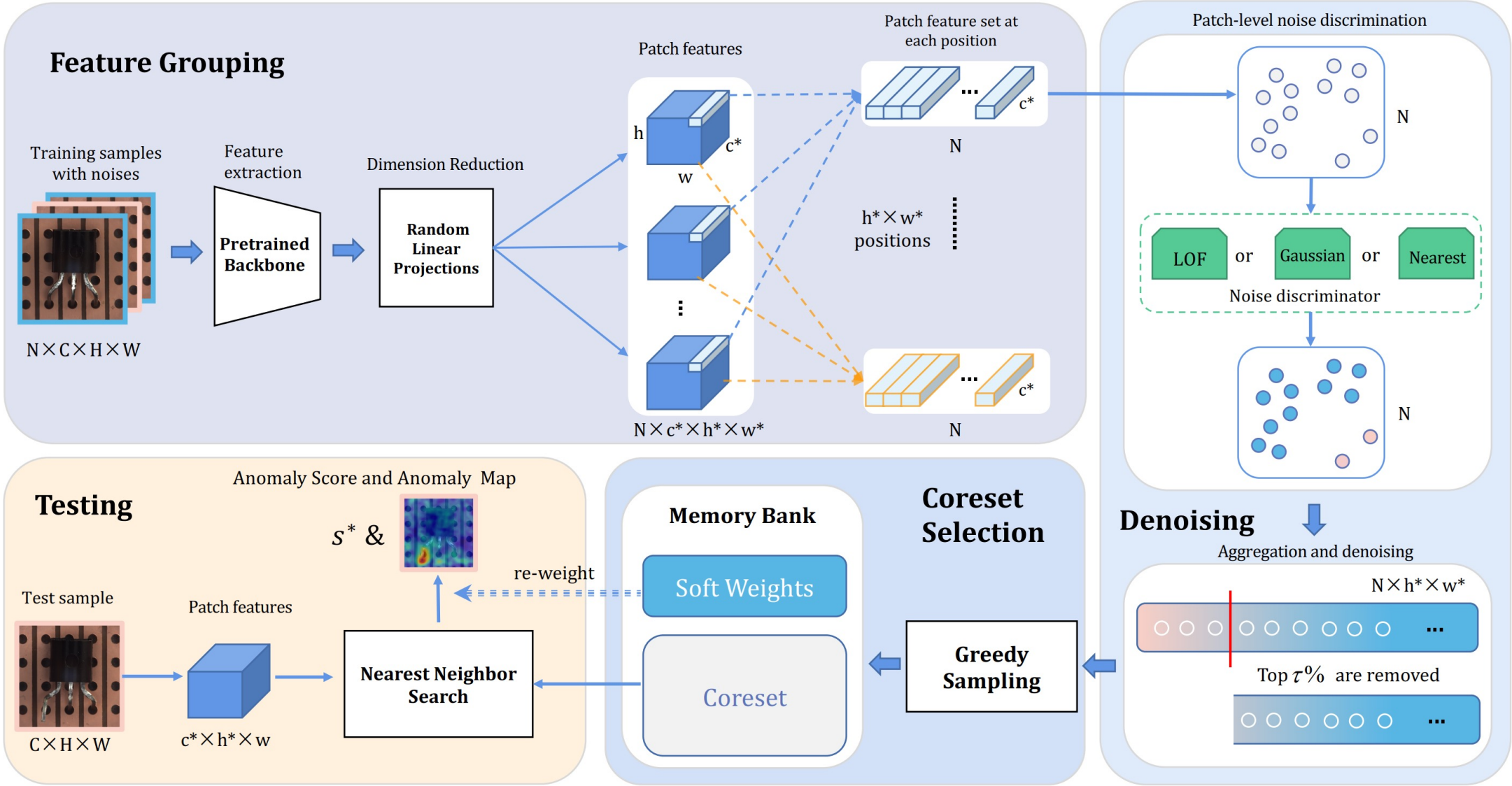
Problem Setup. Noisy training data



A Patch-level Denoising Strategy



Framework


Feature Grouping
Training samples with noises
N×C×H×W
Feature extraction
Pretrained Backbone
Dimension Reduction
Random Linear Projections
Patch features
h
w
c*
N×c*×h*×w*
h*×w* positions
Patch feature set at each position
N
c*
Patch-level noise discrimination
N
LOF
or
Gaussian
or
Nearest
Noise discriminator
N
Denoising
Aggregation and denoising
N×h*×w*
Top τ% are removed
Coreset Selection
Greedy Sampling
Memory Bank
Soft Weights
Coreset
re-weight
Testing
Anomaly Score and Anomaly Map
s* &
Test sample
C×H×W
Patch features
c*×h*×w
Nearest Neighbor Search

Experiments

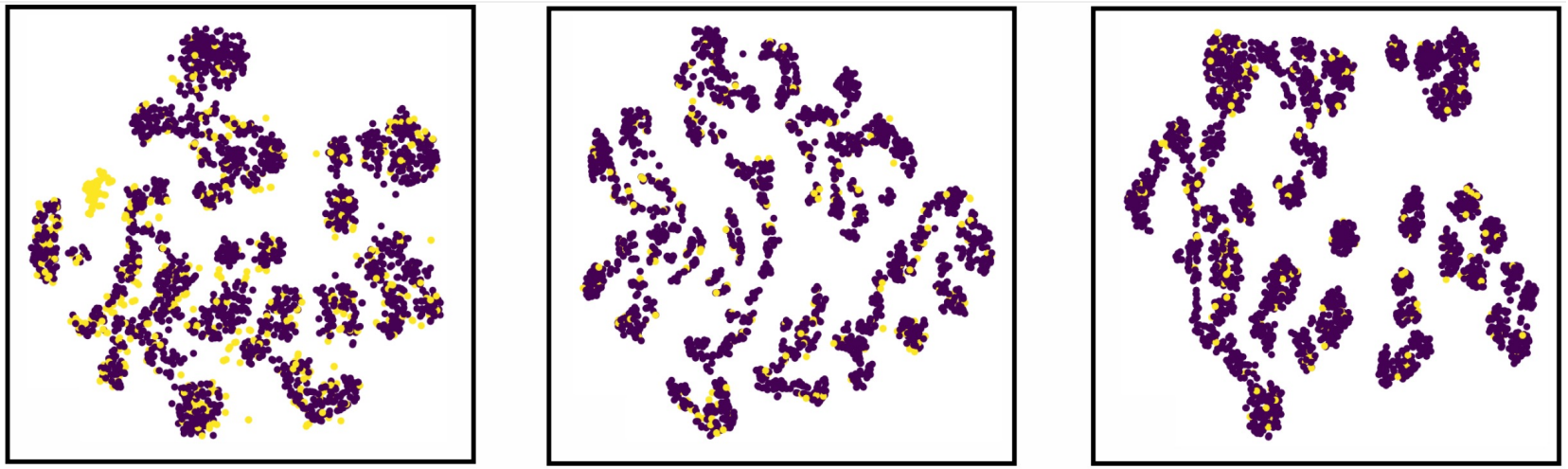
Noise=0.1	No overlap						Overlap			
Category	PaDiM	CFLOW	PatchCore	SoftPatch-nearest	SoftPatch-gaussian	SoftPatch-lof	PaDiM*	PatchCore	PatchCore-random	SoftPatch-lof
Average	0.972	0.969	0.956	0.971	0.977	**0.979**	0.955	0.654	0.951	**0.969**
Gap	-0.007	-0.006	-0.025	-0.008	**-0.001**	-0.002	-0.013	-0.327	-0.021	**-0.012**

Anomaly localization performance on MVTecAD with 10% noise

Experiments

Noise=0.1	No overlap						Overlap			
Category	PaDiM	CFLOW	PatchCore	SoftPatch-nearest	SoftPatch-gaussian	SoftPatch-lof	PaDiM*	PatchCore	PatchCore-random	SoftPatch-lof
Average	0.972	0.969	0.956	0.971	0.977	**0.979**	0.955	0.654	0.951	**0.969**
Gap	-0.007	-0.006	-0.025	-0.008	**-0.001**	-0.002	-0.013	-0.327	-0.021	**-0.012**

Anomaly localization performance on MVTecAD with 10% noise



(a) PatchCore (b) PatchCore-Random (c) Ours

Visualization of the memory banks

Experiments

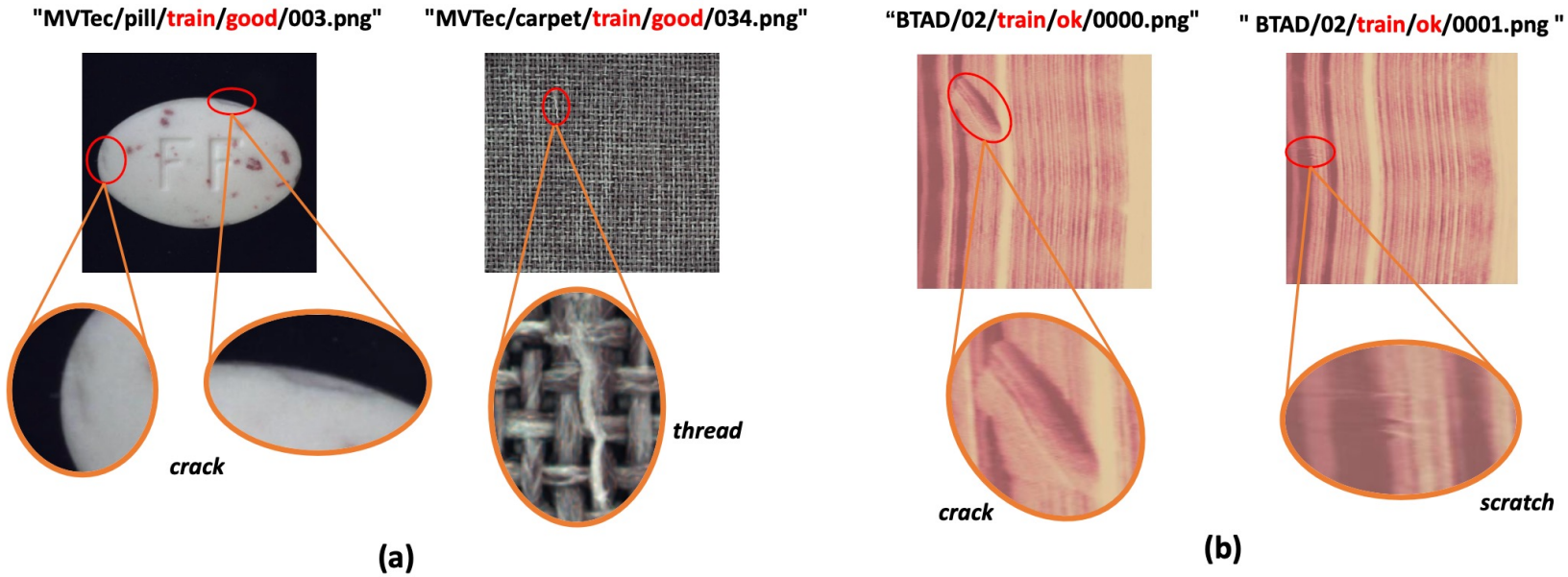
Category	SPADE	P-SVDD	PatchCore	PaDiM	SoftPatch(ours)	Anomaly samples
01	0.914	0.957	**1.000**	**1.000**	0.999	50
02	0.714	0.721	0.871	0.871	**0.934**	200
03	**0.999**	0.821	**0.999**	0.971	0.997	41
Mean	0.876	0.833	0.957	0.947	**0.977**	-

Anomaly localization performance on BTAD without additional noise

Experiments

Category	SPADE	P-SVDD	PatchCore	PaDiM	SoftPatch(ours)	Anomaly samples
01	0.914	0.957	**1.000**	**1.000**	0.999	50
02	0.714	0.721	0.871	0.871	**0.934**	200
03	**0.999**	0.821	**0.999**	0.971	0.997	41
Mean	0.876	0.833	0.957	0.947	**0.977**	-

Anomaly localization performance on BTAD without additional noise



Original noisy examples in (a) MVTec AD and (b) BTAD

Image-level Denoising V.S. Patch-level Denoising

Category	PaDiM*	PaDiM*+ PaDiM*	CFLOW	PaDiM*+ CFLOW	PatchCore	PaDiM*(threshold -0.1)+PatchCore	PaDiM*+ PatchCore	SoftPatch-lof
bottle	0.937	0.994	**1.000**	**1.000**	0.692	0.984	**1.000**	**1.000**
cable	0.680	0.741	0.916	0.841	0.756	0.890	0.888	**0.994**
capsule	0.796	0.854	0.945	0.939	0.783	0.892	0.909	**0.955**
carpet	0.890	0.937	0.960	0.950	0.681	0.963	0.974	**0.993**
grid	0.674	0.765	0.799	0.830	0.526	0.850	0.870	**0.969**
hazelnut	0.543	0.725	0.999	0.990	0.441	0.871	0.929	**1.000**
leather	0.964	0.979	0.996	**1.000**	0.739	0.957	0.989	**1.000**
metal_nut	0.820	0.949	0.957	0.986	0.765	0.965	0.977	**1.000**
pill	0.722	0.745	0.897	0.924	0.770	0.898	0.913	**0.955**
screw	0.567	0.542	0.570	0.639	0.710	0.916	0.907	**0.923**
tile	0.830	0.906	0.980	0.981	0.716	0.939	0.957	**0.981**
toothbrush	0.700	0.869	0.878	0.928	0.800	0.981	**0.997**	0.994
transistor	0.471	0.770	0.872	0.788	0.491	0.777	0.825	**0.999**
wood	0.831	0.966	0.954	0.970	0.579	0.943	0.976	**0.986**
zipper	0.679	0.678	0.931	0.873	0.792	0.909	0.914	**0.974**
Average	0.740	0.828	0.910	0.909	0.683	0.916	0.935	**0.982**

Conclusion

- We study a unique but practical task — **Unsupervised Sensory Anomaly Detection with Noisy Data.**
- We propose a patch-level denoising strategy and a noise-robust AD algorithm, SoftPatch, which construct a clean coreset and an efficient detector according to the grouping noise discriminator.
- We demonstrate that SoftPatch performs well in the settings with additional noisy data as well as the general settings without noise.

Thank you!