1st workshop on Vision-based InduStrial InspectiON, VISION @ CVPR

# Attention Modules Improve Image-Level Anomaly Detection For Industrial Inspection: A DifferNet Case Study

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# 1. Introduction

# Controlled scenario inspection

- MVTec Anomaly Detection (AD) dataset has fomented new classes of AD models
  - ➢ Popular approach: feature-embedding extraction for Unsupervised AD
    - ■ Distribution maps (Normalizing flows)
      - DifferNet [1] , CFLOW-AD [2], FastFlow [3], CS-Flow [4]
    - ■ Patch memory-bank
      - PatchCore [5], PaDiM [6]

# CHALLENGES OF INDUSTRIAL INSPECTION **IN THE WILD**

- Images varying:
  - ➢ Illumination, angulation, orientation, background, resolution, defect size, etc.

- Some defects are unpredictable

- Not many public data

- Common defects in Power Lines
  - ➢ Corrosion (main)
  - ➢ Missing insulator caps
  - ➢ Bird nests

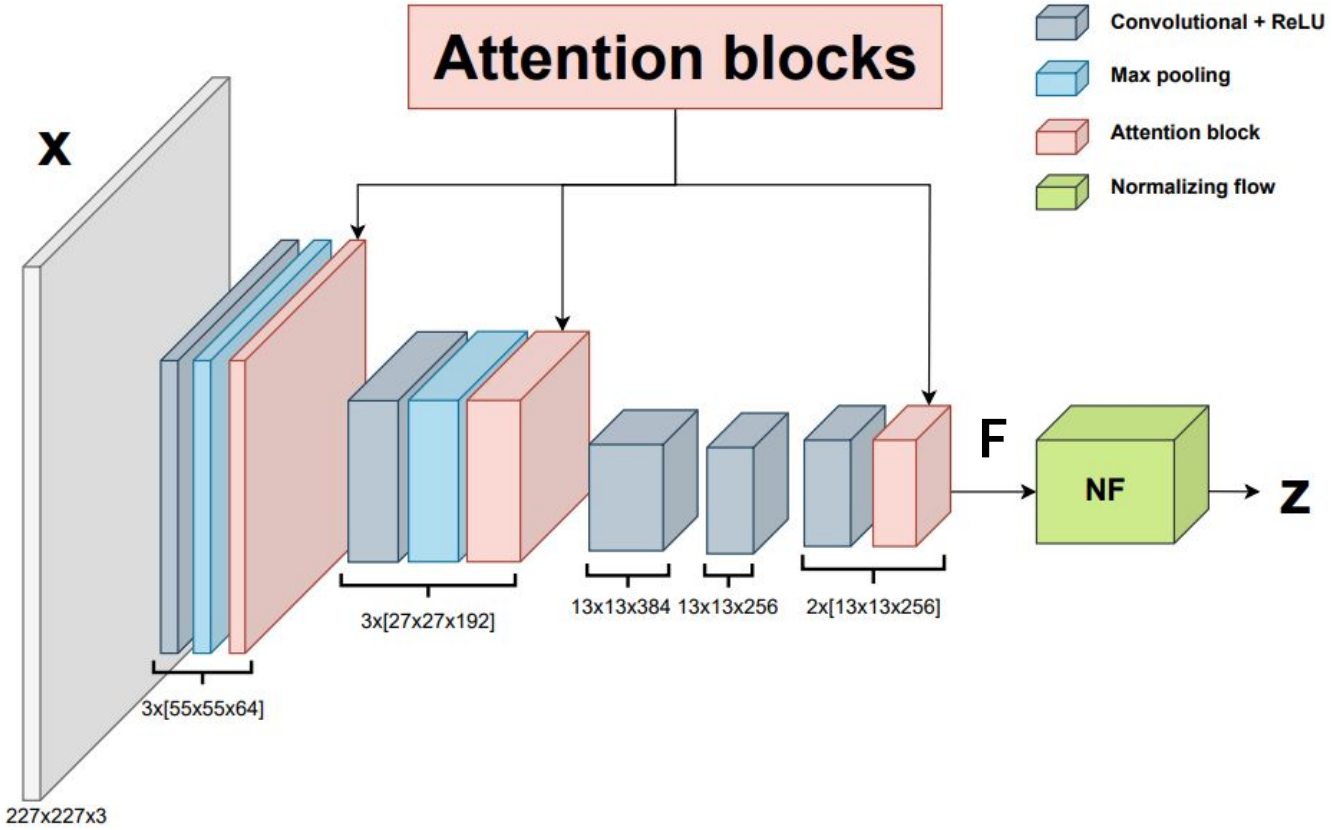
# Hypothesis

- Attention modules can improve accuracy in in-the-wild scenarios
- How to choose the best method to add attention modules?
  - ➢ DifferNet achieved the best out-of-the-box results in InsPLAD-fault
- To be considered a successful hypothesis, attention usage in Unsupervised Anomaly Detection should not present deteriorated performance on inspection in controlled scenarios

# 2. Methods

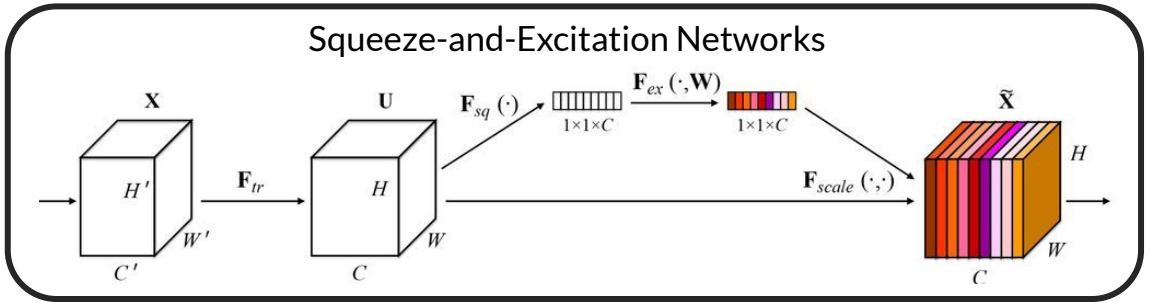
# PROPOSED METHOD

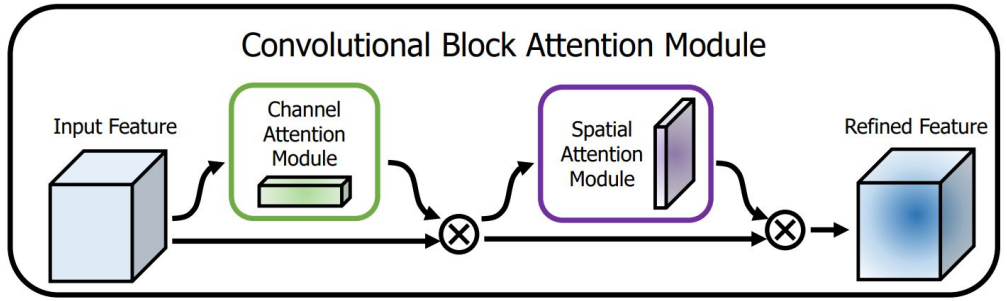
- **AttentDifferNet**
  - ➢ DifferNet
    - ***x***: Input image
    - **F**: Extract features
    - ***z***: Anomaly score
    - Image-level labels only
  - ➢ Attention Modules
    - SENets
    - CBAM



# Attention modules

- Coupling modular attention mechanisms to AD models should help
- Squeeze-and-Excitation Networks & Convolutional Block Attention Modules (SENets & CBAMs) are quite popular and easy to integrate



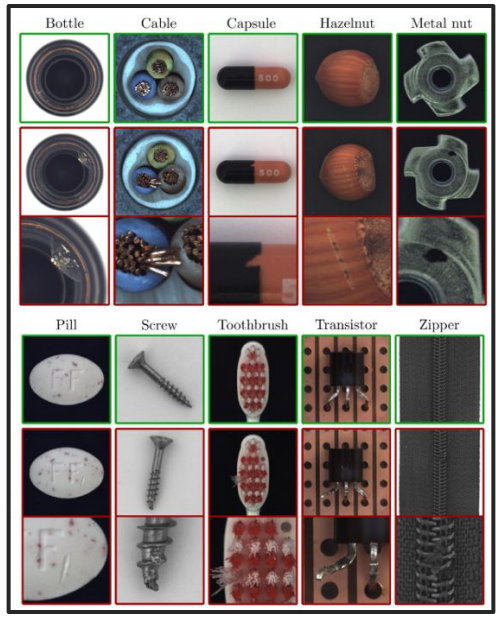



# 3. Datasets

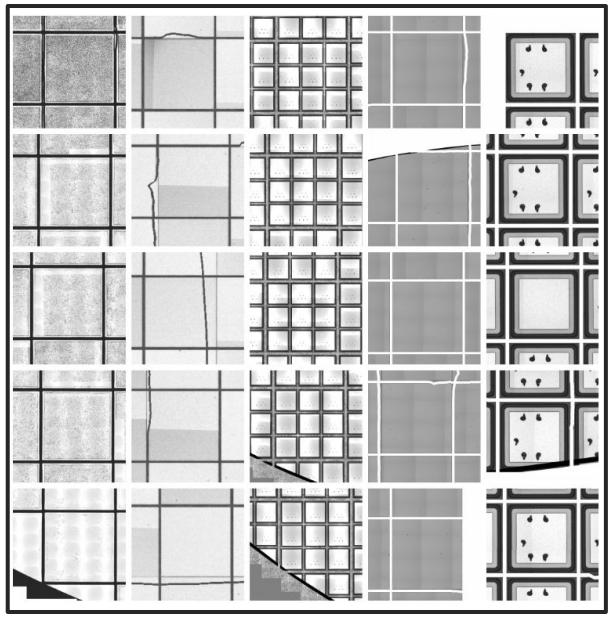
# DATASETS

- InsPLAD-fault **(in-the-wild)** [6]
- MVTec AD
- Semiconductor Wafer Dataset [7]

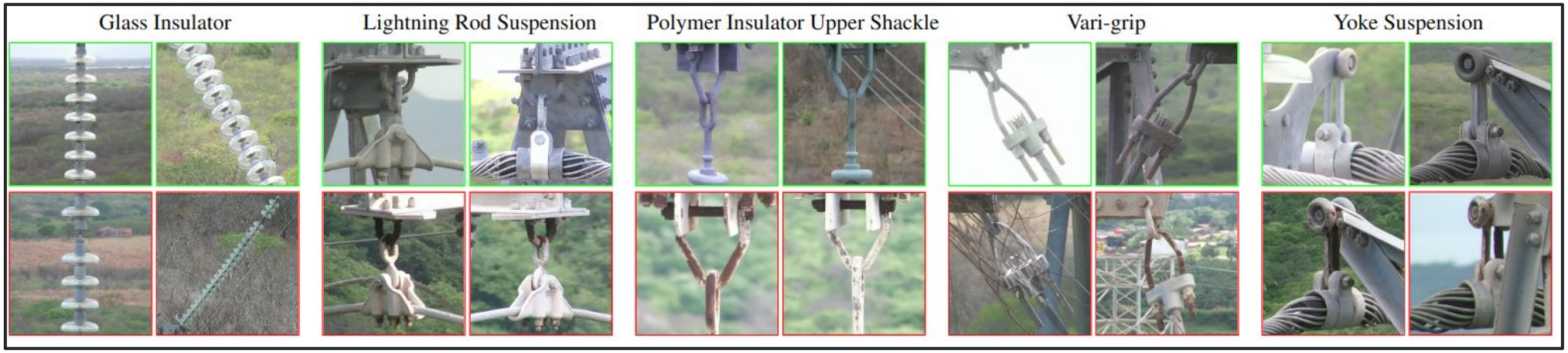
MVTec AD




Semiconductor Wafer Dataset



InsPLAD-fault



# 4. Quantitative results

# RESULTS :: INSPLAD-FAULT DATASET (AUROC)

| Category | DifferNet | AttentDifferNet (SENet) | AttentDifferNet (CBAM) | CS-Flow | PatchCore | Fastflow | CFLOW-AD |
|---|---|---|---|---|---|---|---|
| Glass Insulator | 82,81% | **86,57%** | 81,03% | 85,73% | 78,44% | 80,82% | 82,22% |
| Lightning Rod Suspension | 99,08% | **99,62%** | 99,33% | 96,60% | 85,11% | 87,98% | 95,52% |
| Polymer Insulator Upper Shackle | 92,42% | **94,62%** | 92,10% | 88,40% | 81,02% | 87,57% | 86,60% |
| Vari-Grip | 91,20% | **93,52%** | 88,99% | 91,53% | 91,92% | 81,89% | 90,37% |
| Yoke Suspension | 96,77% | **97,38%** | 96,86% | 90,70% | 58,06% | 80,40% | 83,87% |
| Average AUROC | 92,46% | **94,34%** | 91,66% | 90,59% | 78,91% | 83,73% | 87,72% |

[1]**Bold** font indicates the best category result.
[2]Underlined values show the best result between DifferNet variations.

# RESULTS :: MVTEC AD (AUROC)

| Category | DifferNet | AttentDifferNet (SENet) | AttentDifferNet (CBAM) | CS-Flow | PatchCore | Fastflow | CFLOW-AD |
|---|---|---|---|---|---|---|---|
| Bottle | 99,00% | 99,84% | 99,68% | 99,80% | **100%** | **100%** | **100%** |
| Cable | 95,90% | 98,43% | 96,65% | 99,10% | 99,50% | **100%** | 97,59% |
| Capsule | 86,90% | 93,86% | 92,58% | 97,10% | 98,10% | **100%** | 97,68% |
| Carpet | 92,90% | 93,74% | 95,18% | **100%** | 98,70% | **100%** | 98,73% |
| Grid | 84,00% | 90,89% | 91,23% | 99,00% | 98,20% | **99,70%** | 99,60% |
| Hazelnut | 99,30% | 99,89% | **100,00%** | 99,60% | **100%** | **100%** | 99,98% |
| Leather | 97,10% | 98,61% | 99,32% | 100% | **100%** | **100%** | **100,00%** |
| Metal Nut | 96,10% | 96,53% | 97,70% | 99,10% | **100%** | **100%** | 99,26% |
| Pill | 88,80% | 91,79% | 93,48% | 98,60% | 96,60% | **99,40%** | 96,82% |
| Screw | 96,30% | 96,21% | **98,93%** | 97,60% | 98,10% | 97,80% | 91,89% |
| Tile | 99,40% | **100,00%** | **100,00%** | **100%** | 98,70% | **100%** | 99,88% |
| Toothbrush | 98,60% | **100,00%** | **100,00%** | 91,90% | **100%** | 94,40% | 99,65% |
| Transistor | 91,10% | 94,08% | 93,92% | 99,30% | **100%** | 99,80% | 95,21% |
| Wood | 99,80% | 99,83% | **100,00%** | **100%** | 99,20% | **100%** | 99,12% |
| Zipper | 95,10% | 96,30% | 95,88% | **99,70%** | 98,80% | 99,50% | 98,48% |
| Avg. AUROC | 94,69% | 96,67% | 96,97% | 98,72% | 99,06% | **99,37%** | 98,26% |

# Results :: Semiconductor Wafer Dataset (AUROC)

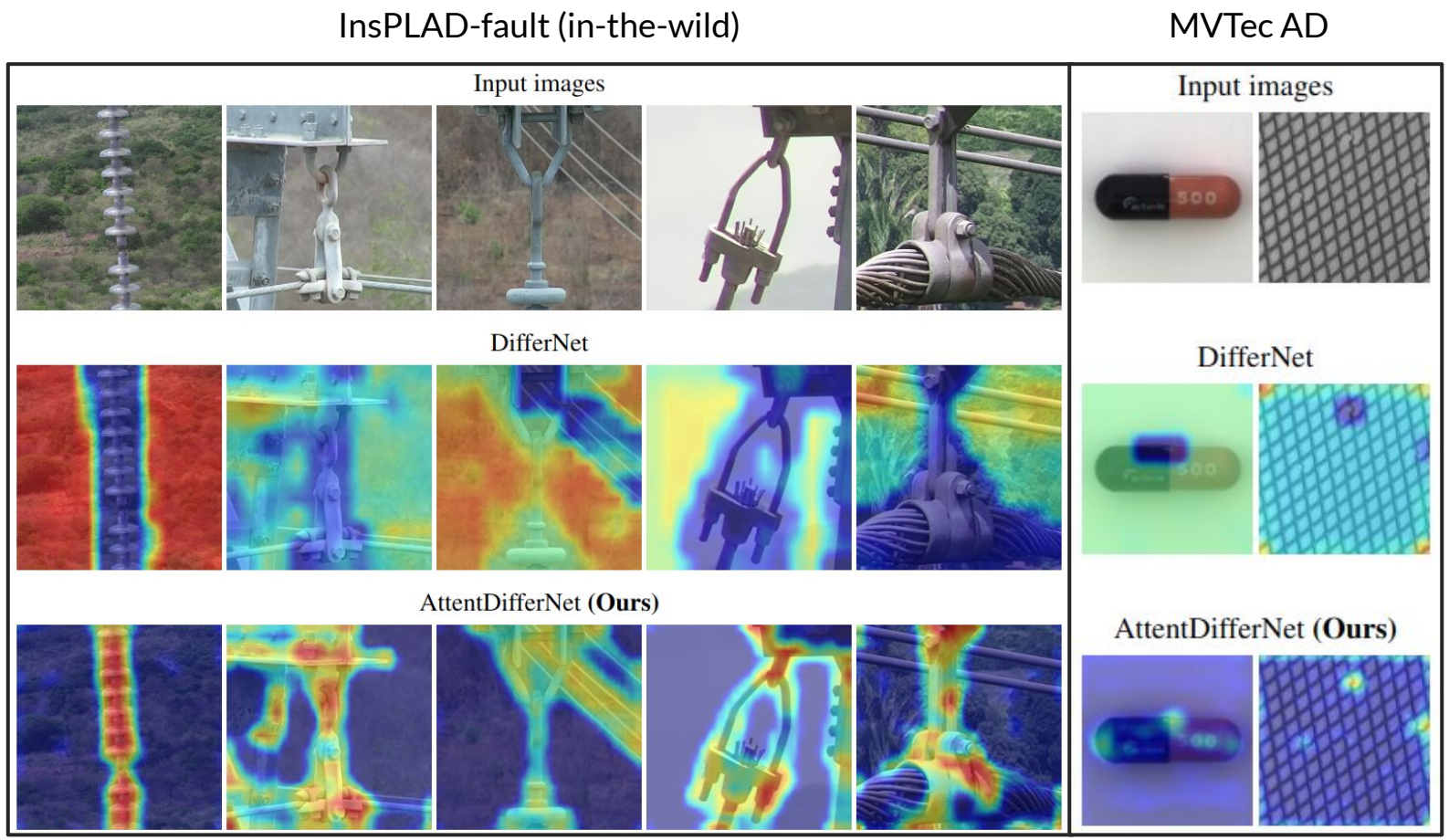
| Category | DifferNet | AttentDifferNet (SENet) | AttentDifferNet (CBAM) | CS-Flow | PatchCore | Fastflow | CFLOW-AD |
|---|---|---|---|---|---|---|---|
| Street Classification | 86,40% | 90,44% | 84,53% | **97,19%** | 79,26% | 80,94% | 70,86% |
| Chip Classification | 91,09% | 89,96% | 93,39% | 90,31% | **93,90%** | 76,27% | 92,01% |
| Average AUROC | 88,74% | 90,20% | 88,96% | **93,75%** | 86,58% | 78,60% | 81,44% |

[1]**Bold** font indicates the best category result.
[2]Underlined values show the best result between DifferNet variations.

# 5. Qualitative results

# Attention Module Impact

- Helps focusing:
  - ➢ on the object itself (in-the-wild case)
  - ➢ on the anomaly itself (controlled env. case)



# 6. Conclusion

# Conclusion

- **AttentDifferNet**, an attention-based DifferNet
  - ➢ Quali-quantitatively superior to DifferNet on all classes of three image-level anomaly detection datasets from multiple domains

- **AttentDifferNet** achieves state-of-the-art performance on InsPLAD-fault, a dataset for image-level anomaly detection in the wild

- The usage of Attention modules improve Unsupervised Anomaly Detection in all three datasets
  - ➢ **94.34** vs 92.46, **96.67** vs 94.69 and **90.2** vs 88.74% (avg. ↑1.77 p.p.)

# References


[1] Rudolph, Marco, Bastian Wandt, and Bodo Rosenhahn. "Same same but differnet: Semi-supervised defect detection with normalizing flows." *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision*. 2021.

[2] Gudovskiy, Denis, Shun Ishizaka, and Kazuki Kozuka. "Cflow-ad: Real-time unsupervised anomaly detection with localization via conditional normalizing flows." *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision*. 2022.

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[4] Rudolph, Marco, et al. "Fully convolutional cross-scale-flows for image-based defect detection." Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision. 2022.

[5] Roth, Karsten, et al. "Towards total recall in industrial anomaly detection." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2022.

[6] Vieira e Silva, A. L. B., et al. “InsPLAD: A Dataset and Benchmark for Power Line Asset Inspection in UAV Images”. *Under Review*. 2023

[7] Schlosser, Tobias, et al. "Improving automated visual fault inspection for semiconductor manufacturing using a hybrid multistage system of deep neural networks." *Journal of Intelligent Manufacturing* 33.4 (2022): 1099-1123.

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