Self-Supervised Image Denoising with Noise Correlation Priors

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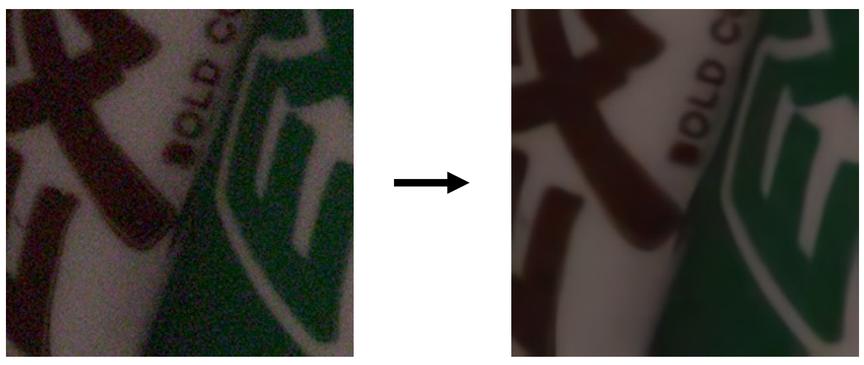
Motivation

Imaging Denoising

- One of the many tasks in the Image Signal Processing Pipeline
- Removes noise while retaining visual details of an image



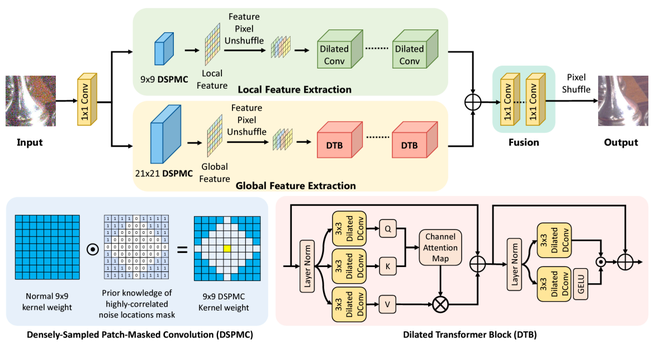
Why Self-Supervised Learning?

- Existing works rely on adding synthetic Gaussian noise for supervised training, which is not realistic
- Obtaining a real-world dataset for supervised training is labor intensive and time-consuming

Related Work

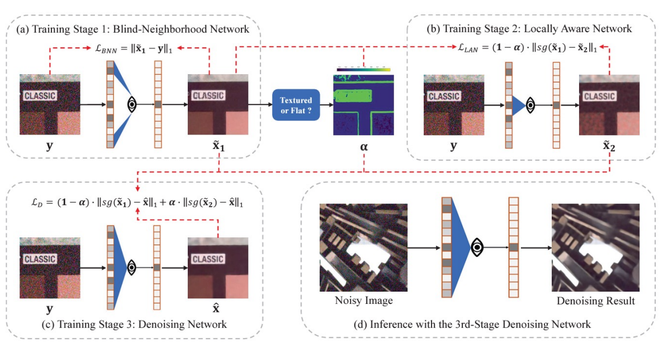
Local and Global Blind-Patch Network (LG-BPN) [2]

- Uses two branches to capture local and global features simultaneously
- The global branch captures a receptive field of 21x21, which is very expensive



Spatially Adaptive Self-Supervised Learning for Real-World Image Denoising (SSID) [3]

- A three-stage model that balances features between flat and texture regions
- We leverage the modularity of the three-stage model and replace its components with some SOTA model parts



References

[1] Abdelhamed, et al., A high-quality denoising dataset for smartphone cameras, CVPR, 2018
[2] Wang, et al., LG-BPN Local and global blind-patch network for self-supervised real-world denoising, CVPR, 2023
[3] Li, et al., Spatially adaptive self-supervised learning for real-world image denoising, CVPR, 2023

New Techniques

Dataset: Smartphone Image Denoising Dataset (SIDD) [1]

Major Contributions

- Investigate pixel-wise noise correlation on a size of 21x21 as image prior
- Rework code provided by SSID into a well-designed library to allow easy switching of BNN and LAN models

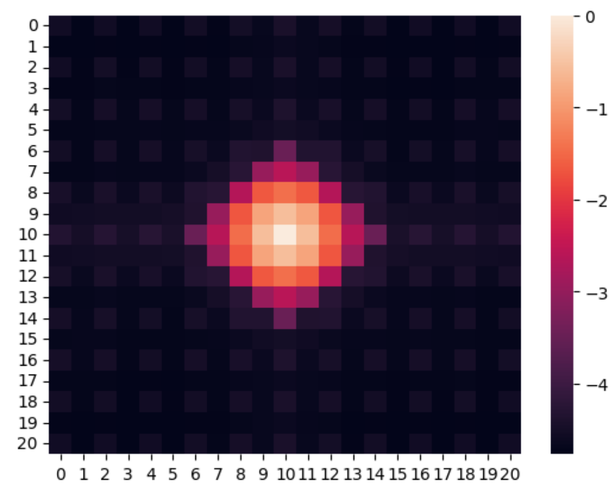
```
model_bnn = SSID_BNN(args.bnn_cfg_path)
model_lan = SSID_LAN(args.lan_cfg_path, model_bnn)
model_unet = SSID_UNet(args.unet_cfg_path, model_bnn, model_lan)
model_unet.train()
```

- Perform additional ablation studies to identify model significance and interpretability
- Replace model components with other SOTA parts to explore model interchangeability
  - LGBPN-related
    - (1) - Replace LGBPN's Local Branch with SSID's BNN
    - (2) - Replace concatenation fusion with average fusion
    - (3) - Replace DCL layers by DTB and lower the number of DTB from 6 to 3 to reduce model complexity
    - (4, 5) - Only use LGBPN's Local (4) / Global (5) Branch
  - SSID-related
    - (1) - Replace SSID's BNN with LGBPN's Local Branch
    - (2) - Replace LAN's loss function to supervise from the noisy image instead of BNN's results

Experimental Results

Correlation Map between image pixels

- Noise are mostly correlated within a 9x9 receptive field
- We observe an unexpected fluctuation pattern of noise outside the 9x9 receptive field



Model Results

	PSNR	SSIM
LGBPN (Original)	37.280	0.9360
LGBPN (1)	33.546	0.8446
LGBPN (2)	37.138	0.8858
LGBPN (3)	36.798	0.8810
LGBPN (4) / SSID (1 - Stage 1)	36.038	0.8629
LGBPN (5)	36.212	0.8614
SSID (Original)	37.390	0.9340
SSID (1)	TBD (Stage 3 In Progress)	
SSID (2)	TBD