# Single Image Super-Resolution with Dynamic Residual Connection

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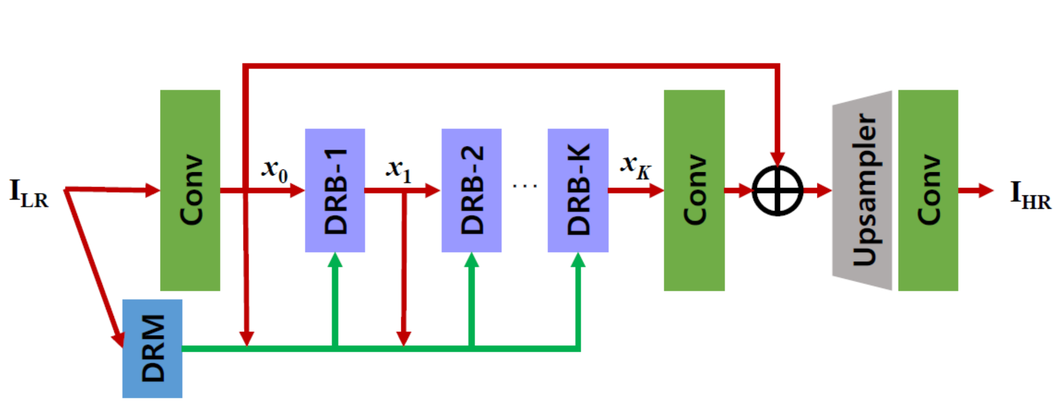
## Abstract

✓ There have been attempts to solve the Single Image Super-resolution problem using lightweight networks, considering limited computational resources for real-world applications.

✓ In previous works, residual paths in networks are pre-fixed and manually designed by human researchers.

✓ The proposed method allows the network to dynamically select residual paths depending on the input image, based on the idea of attention mechanism.

## Network Structure

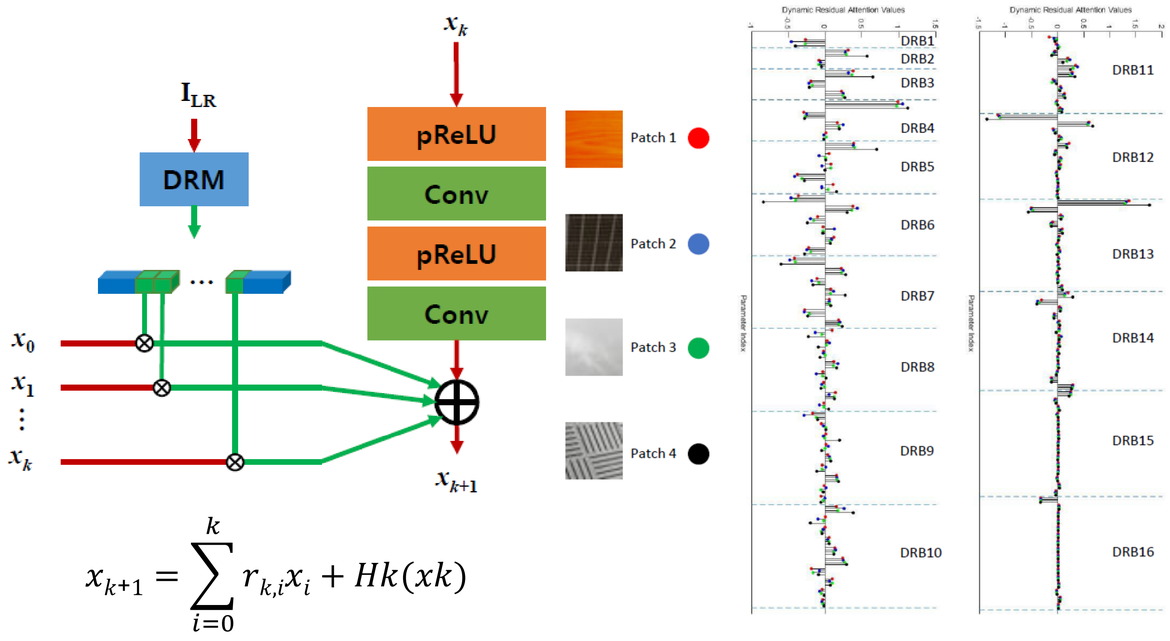



✓ Dynamic Residual Attention Network (DRAN) consists of five main parts: two convolution layers at the input and output side each, set of Dynamic Residual Blocks (DRBs), the Upsampler network and Dynamic Residual Module (DRM).

✓ DRB selectively accepts necessary information from preceding DRBs and sends the processed feature to following DRBs.

✓ DRM controls residual connection between DRBs according to the input image.

## Dynamic Residual Attention



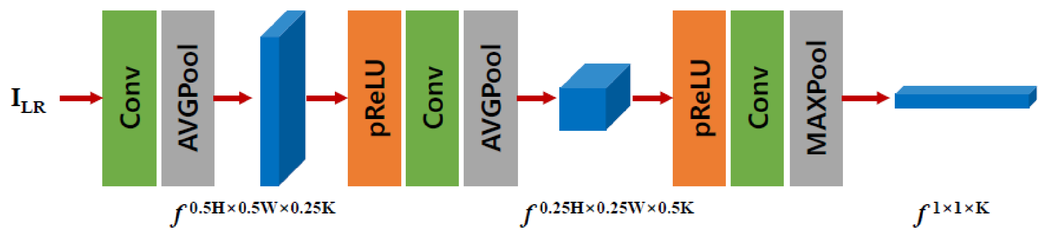

$$x_{k+1} = \sum_{i=0}^{k} r_{k,i} x_i + Hk(xk)$$

✓ DRAN exploits selected features in the shallow part of the network considering the input image, which allows the DRB to use the features of various depths as needed.

✓ The residual attention parameters emphasize more important features or weaken unnecessary features from preceding building blocks.

✓ Proposed dynamic residual path structure guarantees more diverse combination of features compared to previous methods with pre-fixed residual paths.

## Dynamic Residual Module



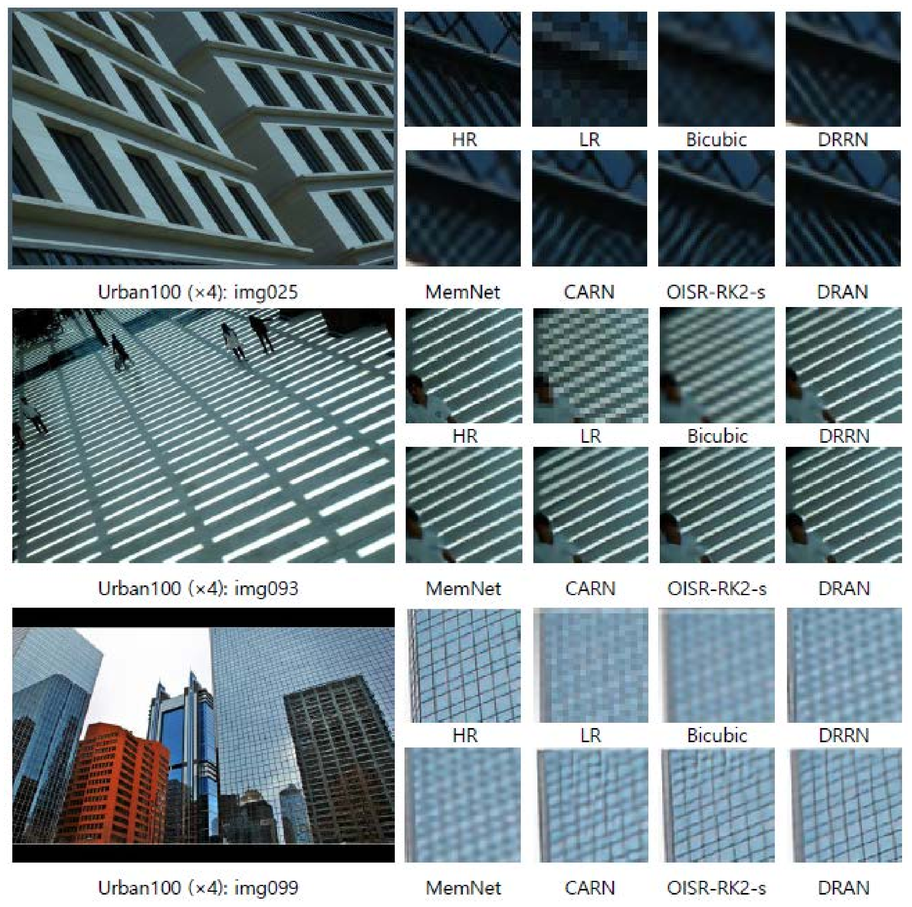

✓ Dynamic Residual Module uses the input image as prior information to compute optimal residual path attention parameter.

## Qualitative Results

| Scale | Method | Params | MAC | Set5 PSNR/SSIM | Set14 PSNR/SSIM | B100 PSNR/SSIM | Urban100 PSNR/SSIM |
|---|---|---|---|---|---|---|---|
| x2 | Bicubic | - | - | 33.66 / 0.9299 | 30.24 / 0.8688 | 29.56 / 0.8431 | 26.88 / 0.8403 |
| | FSRCNN | 0.01M | 6.0G | 37.00 / 0.9558 | 32.63 / 0.9088 | 31.53 / 0.8920 | 29.88 / 0.9020 |
| | DRCN | 1.77M | 17974G | 37.63 / 0.9588 | 33.04 / 0.9118 | 31.85 / 0.8942 | 30.75 / 0.9133 |
| | DRRN | 0.30M | 6796.9G | 37.74 / 0.9591 | 33.23 / 0.9136 | 32.05 / 0.8973 | 31.23 / 0.9188 |
| | MemNet | 0.68M | 623.9G | 37.78 / 0.9597 | 33.28 / 0.9143 | 32.08 / 0.8978 | 31.31 / 0.9195 |
| | SelNet | 0.97M | 225.7G | 37.89 / 0.9598 | 33.61 / 0.9160 | 32.08 / 0.8984 | - |
| | CARN | 1.59M | 222.8G | 37.76 / 0.9590 | 33.52 / 0.9166 | 32.09 / 0.8978 | 31.92 / 0.9256 |
| | FALSR-A | 1.02M | 234.7G | 37.82 / 0.9595 | 33.55 / 0.9168 | 32.12 / 0.8987 | 31.93 / 0.9256 |
| | FALSR-B | 0.33M | 74.7G | 37.61 / 0.9585 | 33.29 / 0.9143 | 31.97 / 0.8967 | 31.28 / 0.9191 |
| | FALSR-C | 0.41M | 93.7G | 37.66 / 0.9586 | 33.26 / 0.9140 | 31.96 / 0.8965 | 31.24 / 0.9187 |
| | OISR-RK2-s | 1.37M | 316.2G | 37.98 / 0.9604 | 33.58 / 0.9172 | 32.18 / 0.8996 | 32.09 / 0.9281 |
| | OISR-LF-s | 1.37M | 316.2G | 38.02 / 0.9605 | 33.62 / 0.9178 | 32.20 / 0.9000 | 32.21 / 0.9290 |
| | DRAN-s | 0.79M | 180.6G | 37.89 / 0.9601 | 33.49 / 0.9171 | 32.14 / 0.8999 | 31.98 / 0.9272 |
| | DRAN | 1.48M | 318.9G | 38.05 / 0.9607 | 33.65 / 0.9179 | 32.20 / 0.9002 | 32.25 / 0.9296 |
| x3 | Bicubic | - | - | 30.39 / 0.8682 | 27.55 / 0.7742 | 27.21 / 0.7385 | 24.46 / 0.7349 |
| | FSRCNN | 0.01M | 5.0G | 33.16 / 0.9140 | 29.43 / 0.8242 | 28.53 / 0.7910 | 26.43 / 0.8080 |
| | DRCN | 1.77M | 17974G | 33.82 / 0.9226 | 29.76 / 0.8311 | 28.80 / 0.7963 | 27.15 / 0.8276 |
| | DRRN | 0.30M | 6796.9G | 34.03 / 0.9244 | 29.96 / 0.8349 | 28.95 / 0.8004 | 27.53 / 0.8378 |
| | MemNet | 0.68M | 623.9G | 34.09 / 0.9248 | 30.00 / 0.8385 | 28.96 / 0.8001 | 27.56 / 0.8376 |
| | SelNet | 1.16M | 120.0G | 34.27 / 0.9257 | 30.30 / 0.8399 | 28.97 / 0.8025 | - |
| | CARN | 1.59M | 118.8G | 34.29 / 0.9255 | 30.29 / 0.8407 | 29.06 / 0.8034 | 28.06 / 0.8493 |
| | OISR-RK2-s | 1.55M | 160.1G | 34.43 / 0.9273 | 30.33 / 0.8420 | 29.10 / 0.8053 | 28.20 / 0.8534 |
| | OISR-LF-s | 1.55M | 160.1G | 34.39 / 0.9272 | 30.35 / 0.8426 | 29.11 / 0.8058 | 28.24 / 0.8544 |
| | DRAN-s | 0.97M | 100.0G | 34.30 / 0.9261 | 30.27 / 0.8413 | 29.05 / 0.8049 | 28.07 / 0.8509 |
| | DRAN | 1.66M | 161.5G | 34.50 / 0.9276 | 30.40 / 0.8437 | 29.13 / 0.8068 | 28.35 / 0.8567 |
| x4 | Bicubic | - | - | 28.42 / 0.8104 | 26.00 / 0.7027 | 25.96 / 0.6675 | 23.14 / 0.6577 |
| | FSRCNN | 0.01M | 4.6G | 30.48 / 0.8628 | 27.49 / 0.7503 | 26.90 / 0.7101 | 24.52 / 0.7221 |
| | DRCN | 1.77M | 17974G | 31.53 / 0.8854 | 28.02 / 0.7670 | 27.23 / 0.7233 | 25.14 / 0.7510 |
| | DRRN | 0.30M | 6796.9G | 31.68 / 0.8888 | 28.21 / 0.7720 | 27.38 / 0.7284 | 25.44 / 0.7638 |
| | MemNet | 0.68M | 623.9G | 31.74 / 0.8893 | 28.26 / 0.7723 | 27.40 / 0.7281 | 25.50 / 0.7630 |
| | SelNet | 1.42M | 83.1G | 32.00 / 0.8931 | 28.49 / 0.7783 | 27.44 / 0.7325 | - |
| | CARN | 1.59M | 90.9G | 32.13 / 0.8937 | 28.60 / 0.7806 | 27.58 / 0.7349 | 26.07 / 0.7837 |
| | OISR-RK2-s | 1.52M | 114.2G | 32.21 / 0.8950 | 28.63 / 0.7822 | 27.58 / 0.7364 | 26.14 / 0.7874 |
| | OISR-LF-s | 1.52M | 114.2G | 32.14 / 0.8947 | 28.63 / 0.7819 | 27.60 / 0.7369 | 26.17 / 0.7888 |
| | DRAN-s | 0.94M | 80.3G | 32.09 / 0.8925 | 28.54 / 0.7810 | 27.53 / 0.7356 | 25.98 / 0.7835 |
| | DRAN | 1.62M | 114.9G | 32.27 / 0.8947 | 28.63 / 0.7833 | 27.61 / 0.7380 | 26.23 / 0.7909 |

✓ Quantitative comparisons of our models with the previous lightweight models on benchmark datasets. The best performance is shown in red and the second best is shown in blue. The small-scale versions are suffixed by "-s."

## Qualitative Results




✓ Qualitative comparisons for ×4 super-resolution with our method and other state-of-the-arts on Urban100 datasets.