# Lightweight Real-Time Image Super-Resolution Network for 4K Images

Ganzorig Gankhuyag*, Kihwan Yoon*, Jinman Park, Haeng Seon Son, Kyoungwon Min

* : Equal Contribution

# Key Contribution

- We proposed the lightweight real-time image super resolution (LRSRN) network structure that simultaneously achieves high accuracy and real-time speed.

  - Low computational complexity and high accuracy compared to traditional SISR methods

- We employed a reparameterized convolution (RepConv) layer, which enhances image quality while maintaining model size and inference speed

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# Network Architecture

- We applied RepConv to each convolution layer, which is a more efficient method
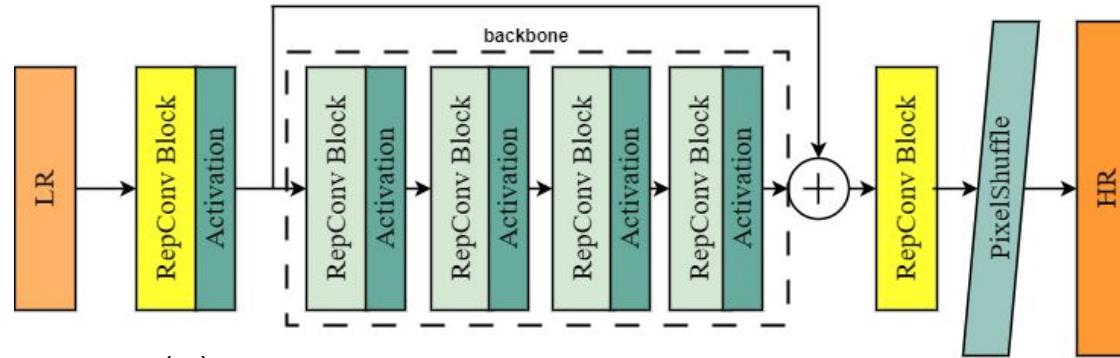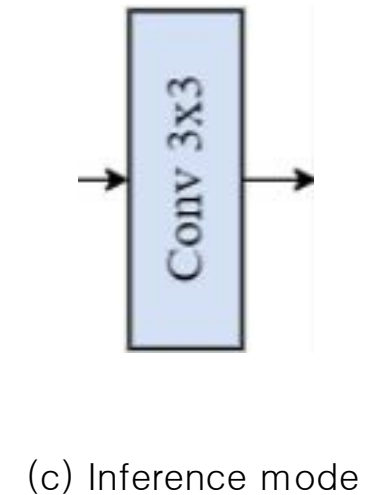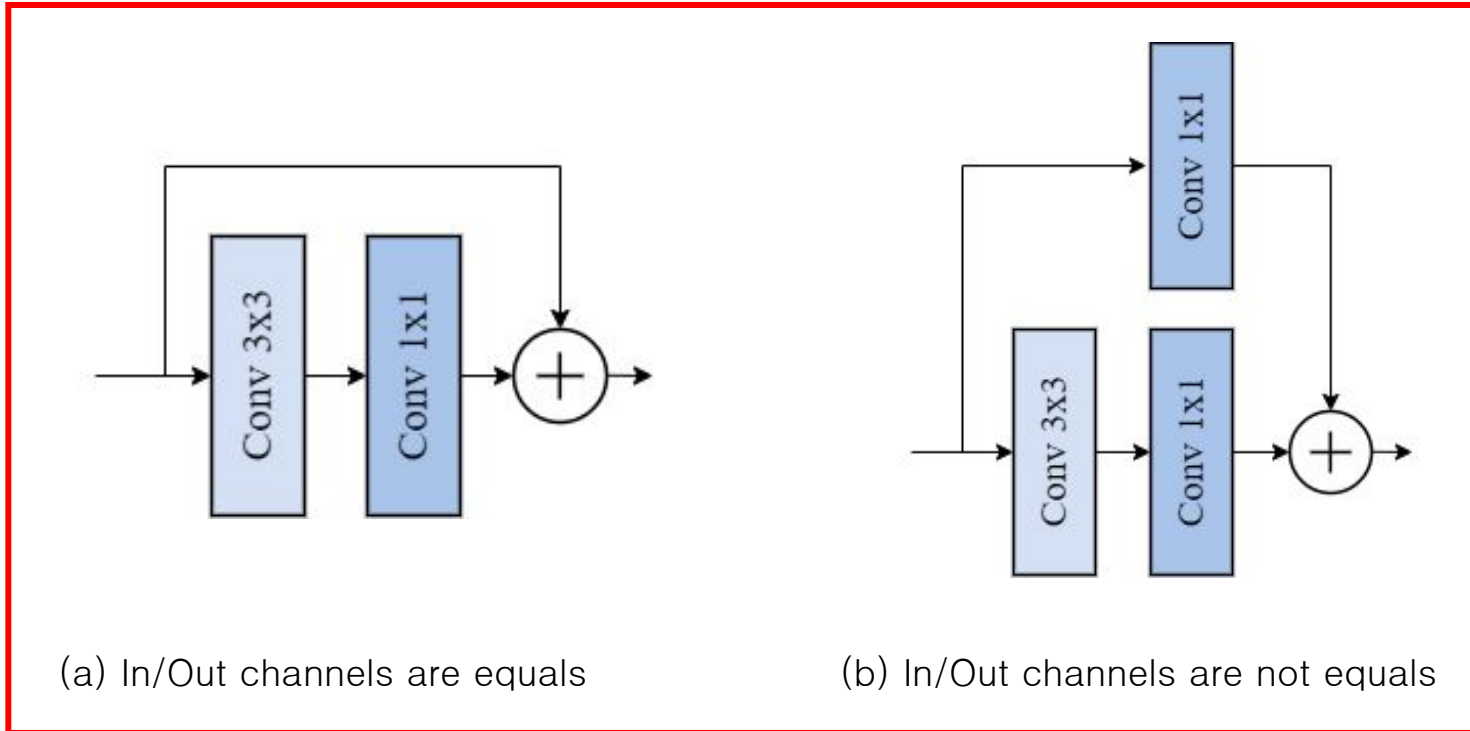


(a) The Training mode of proposed network
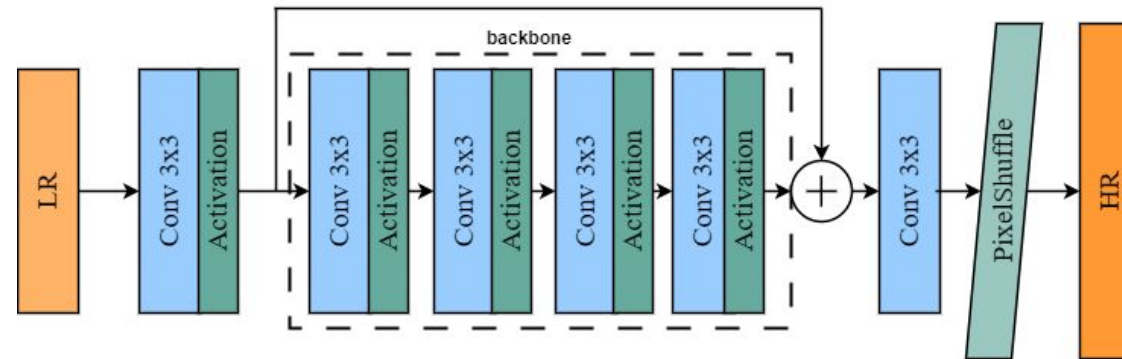
(b) The inference mode of proposed network

# Reparameterized Block

- We applied RepConv to each convolution layer, which is a more efficient method.

- We applied an advanced version of RepConv block when In/Our channels are not equals



(a) In/Out channels are equals        (b) In/Out channels are not equals        (c) Inference mode

# Experimental Results

| Backbone | Channels | Patch Sizes | RepConv | Fine-Tune | NTIRE2023 val PSNR | NTIRE2023 val SSIM | Inference Time (ms) | Scores |
|---|---|---|---|---|---|---|---|---|
| 5 | 64 | 96 | X | X | 31.897 | 0.9291 | 26.62 | 4.47 |
| 4 | 64 | 96 | X | X | 31.920 | 0.9296 | 22.19 | 4.98 |
| 4 | 32 | 96 | X | X | 31.909 | 0.9295 | 9.77 | 7.44 |
| 4 | 32 | 192 | X | X | 31.900 | 0.9294 | 9.77 | 7.40 |
| 4 | 32 | 192 | O | X | 32.784 | 0.9382 | 9.77 | 13.66 |
| 4 | 32 | 192 | O | DIV2K [1] | 32.812 | 0.9386 | 9.77 | 13.92 |
| 4 | 32 | 192 | O | Proposed work | 32.831 | 0.9388 | 9.77 | 14.11 |

Ablation study results on DIV2K val dataset

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# Experimental Results

| Scale | Network | Set5 | | | Set14 | | | B100 | | | Urban100 | | | DIV2K | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PSNR | SSIM | PSNR (Y) | PSNR | SSIM | PSNR (Y) | PSNR | SSIM | PSNR (Y) | PSNR | SSIM | PSNR (Y) | PSNR | SSIM | PSNR (Y) |
| X2 | Bicubic | 29.96 | 0.8676 | 31.86 | 27.38 | 0.8121 | 28.58 | 27.67 | 0.8169 | 28.05 | 24.98 | 0.8069 | 25.53 | 29.85 | 0.8662 | 30.79 |
| | FSRCNN [13] | 31.36 | 0.8892 | 33.41 | 28.38 | 0.8335 | 28.81 | 28.57 | 0.8379 | 29.01 | 26.44 | 0.8440 | 27.16 | 30.39 | 0.8849 | 31.95 |
| | SESR [5] | 31.71 | 0.8944 | 33.98 | 28.78 | 0.8423 | 30.29 | 28.94 | 0.8461 | 29.37 | 27.38 | 0.8641 | 28.20 | 31.40 | 0.8923 | 32.47 |
| | IMDN [20] | 32.24 | 0.9022 | 34.32 | 29.34 | 0.8525 | 30.66 | 29.26 | 0.8521 | 29.65 | 28.38 | 0.8821 | 29.18 | 31.98 | 0.9006 | 32.90 |
| | RTSRN [40] | 30.33 | 0.8713 | 32.31 | 27.72 | 0.8196 | 29.06 | 28.02 | 0.8171 | 28.44 | 25.41 | 0.8171 | 26.05 | 30.20 | 0.8719 | 31.23 |
| | SCSRN [16] | 31.72 | 0.8952 | 33.99 | 28.78 | 0.8426 | 30.29 | 28.92 | 0.8466 | 29.35 | 27.34 | 0.8640 | 28.15 | 31.41 | 0.8925 | 32.46 |
| | Proposed work | 31.84 | 0.8969 | 33.92 | 28.84 | 0.8436 | 30.26 | 28.93 | 0.8470 | 29.34 | 27.35 | 0.8641 | 28.11 | 31.44 | 0.8933 | 32.41 |
| X3 | Bicubic | 27.28 | 0.7962 | 28.84 | 25.16 | 0.7190 | 26.11 | 25.43 | 0.7098 | 25.76 | 22.71 | 0.7040 | 23.13 | 27.42 | 0.7918 | 28.16 |
| | FSRCNN [13] | 28.41 | 0.8284 | 30.03 | 25.96 | 0.7436 | 27.06 | 26.03 | 0.7314 | 26.39 | 23.63 | 0.7430 | 24.12 | 28.17 | 0.8127 | 28.96 |
| | SESR [5] | 29.05 | 0.8429 | 30.84 | 26.39 | 0.7590 | 27.51 | 26.40 | 0.7432 | 26.73 | 24.37 | 0.7713 | 24.91 | 28.62 | 0.8240 | 29.42 |
| | IMDN [20] | 29.68 | 0.8559 | 31.32 | 26.86 | 0.7714 | 27.84 | 26.67 | 0.7514 | 26.96 | 25.13 | 0.7961 | 25.63 | 29.13 | 0.8357 | 29.79 |
| | RTSRN [40] | 27.55 | 0.7997 | 29.16 | 25.4 | 0.7263 | 26.43 | 25.62 | 0.7196 | 25.98 | 22.97 | 0.7137 | 23.44 | 27.63 | 0.7974 | 28.43 |
| | SCSRN [16] | 29.06 | 0.8431 | 30.84 | 26.41 | 0.7597 | 27.53 | 26.40 | 0.7449 | 26.74 | 24.41 | 0.7728 | 24.94 | 28.65 | 0.8253 | 29.44 |
| | Proposed work | 29.13 | 0.8459 | 30.75 | 26.47 | 0.7606 | 27.51 | 26.40 | 0.7443 | 26.72 | 24.40 | 0.7713 | 24.88 | 28.69 | 0.8255 | 29.41 |

Qualitative results comparison on benchmark datasets.

# Experimental Results

| Scale | Models | Params (K) | Inference Time (ms) | NTIRE2023 val (PSNR db) [11] | Scores |
|-------|--------|-----------|---------------------|------------------------------|--------|
| X2 | FSRCNN [13] | 25.35 | 33.05 | 29.60 | 5.65 |
| | SESR [5] | 23.64 | 12.52 | 29.95 | 10.99 |
| | IMDN [20] | 873.20 | 143.34 | 30.44 | 4.75 |
| | RTSRN [40] | 193.40 | 23.37 | 29.14 | 4.77 |
| | SCSRN [16] | 46.80 | 10.24 | 29.95 | 12.15 |
| | Proposed work | 41.40 | 9.77 | 30.15 | 14.11 |
| X3 | FSRCNN [13] | 25.35 | 14.68 | 29.60 | 7.91 |
| | SESR [5] | 23.64 | 6.11 | 29.95 | 15.63 |
| | IMDN [20] | 881.88 | 63.97 | 30.44 | 6.78 |
| | RTSRN [40] | 202.00 | 10.67 | 29.14 | 6.74 |
| | SCSRN [16] | 53.01 | 5.05 | 29.95 | 17.19 |
| | Proposed work | 45.70 | 4.75 | 30.15 | 20.36 |

Qualitative results comparison on NTIRE validation dataset

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# Experimental Results
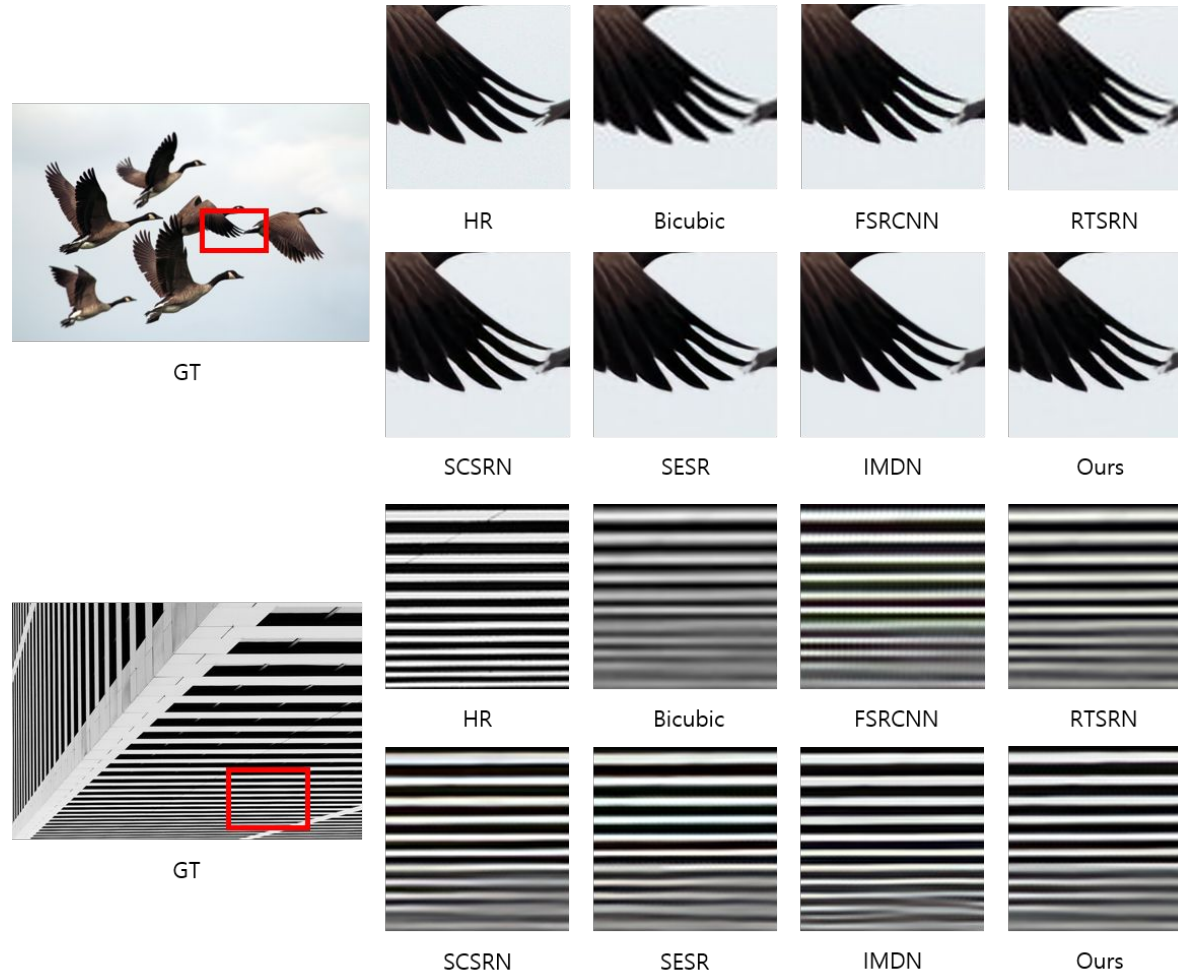
# Experimental Results

| Scale | Network | NTIRE2023 test [11] | | | |
|---|---|---|---|---|---|
| | | PSNR | SSIM | PSNR (Y) | Inference Time |
| X2 | Bicubuc | 33.92 | 0.8829 | 36.66 | 0.45 |
| | Noah_TerminalVision | 35.02 | 0.8957 | 37.74 | 3.19 |
| | ALONG | 34.68 | 0.8906 | 37.38 | 1.91 |
| | RTVSR | 34.71 | 0.8910 | 37.50 | 2.24 |
| | Team OV | 34.62 | 0.8899 | 37.45 | 2.91 |
| | Proposed work | 35.02 | 0.8948 | 37.76 | 11.19 |
| X3 | Bicubuc | 31.30 | 0.8246 | 33.82 | 0.5 |
| | Aselsan Research | 32.06 | 0.8344 | 34.56 | 1.17 |
| | Team OV | 32.17 | 0.8376 | 34.72 | 1.51 |
| | ALONG | 32.18 | 0.8367 | 34.66 | 1.66 |
| | RTVSR | 32.22 | 0.8372 | 34.77 | 1.96 |
| | Proposed work | 32.59 | 0.8446 | 35.05 | 5.47 |

# Paper and Code link



Code link



Paper link

If you have any questions, please contact us

gnzrg25@gmail.com
rlghksdbs@gmail.com