NTIRE 2022 Challenge on Efficient Super-Resolution: Methods and Results

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Introduction

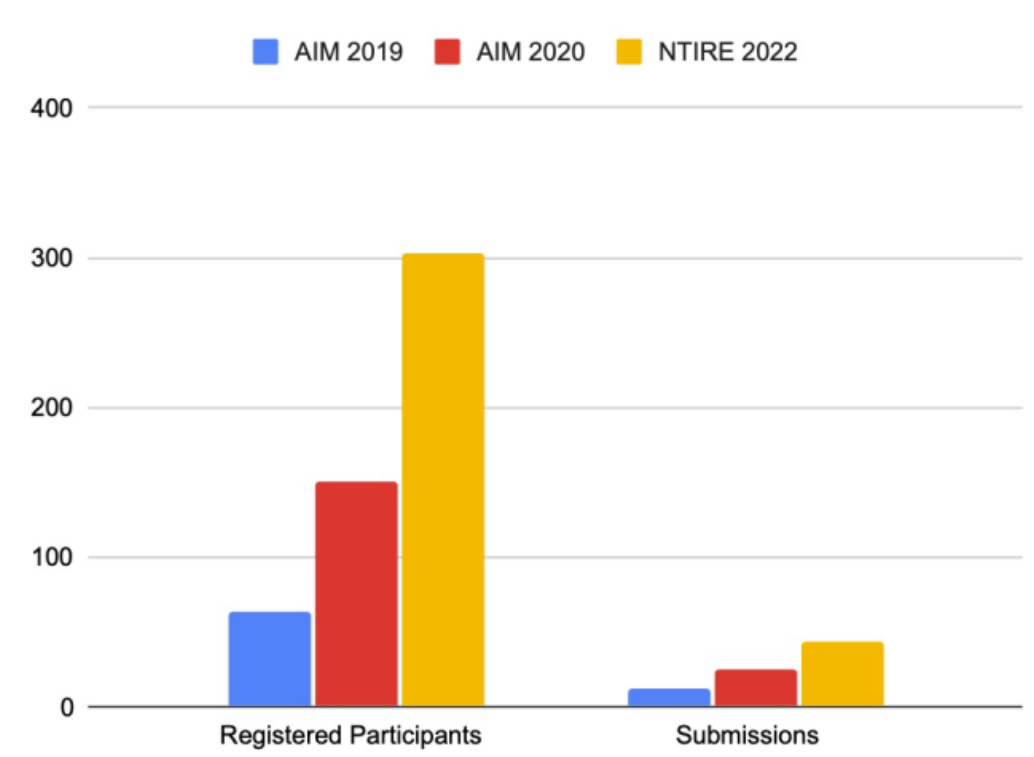
The task of the challenge was to super-resolve an input image with a magnification factor of x4 based on pairs of low and corresponding high-resolution images. The aim was to design a network for single image super-resolution that achieved improvement of efficiency measured according to several metrics including runtime, parameters, FLOPs, activations, and memory consumption while at least maintaining the PSNR of 29.00dB on DIV2K validation set. IMDN is set as the baseline for efficiency measurement. The challenge had 3 tracks including the main track (runtime), sub-track one (model complexity), and sub-track two (overall performance).

Challenge Tracks

Main Track: Runtime Track. In this track, the practical runtime performance of the submissions is evaluated. The rankings of the teams are determined directly by the absolute value of the average runtime on the validation set and test set.

Sub-Track 1: Model Complexity Track. In this track, the number of parameters and FLOPs are considered. And the rankings of the two metrics are summed up to determine a final ranking in this track.

Sub-Track 2: Overall Performance Track. In this track, all the five metrics mentioned in the description of the challenge including runtime, parameters, FLOPs, activations, and GPU memory are considered.



Results

Team	Main Track	Sub-Track 1	Sub-Track 2	PSNR [Val.]	PSNR [Test]	Ave. Time [ms]	#Params [M]	FLOPs [G]	#Acts [M]	GPU Mem. [M]	#Conv
ByteESR	1	$22_{(11)}$	$33_{(2)}$	29.00	28.72	$27.11_{(1)}$	$0.317_{(11)}$	$19.70_{(11)}$	$80.05_{(6)}$	$377.91_{(4)}$	39
NJU_Jet	2	$37_{(18)}$	$44_{(6)}$	29.00	28.69	$28.07_{(2)}$	$0.341_{(18)}$	$22.28_{(19)}$	$72.09_{(4)}$	$204.60_{(1)}$	34
NEESR	3	$10_{(4)}$	$27_{(1)}$	29.01	28.71	$29.97_{(3)}$	$0.272_{(4)}$	$16.86_{(6)}$	$79.59_{(5)}$	$575.99_{(9)}$	59
Super	4	$26_{(12)}$	$55_{(10)}$	29.00	28.71	$32.09_{(4)}$	$0.326_{(14)}$	$20.06_{(12)}$	$93.82_{(10)}$	$663.07_{(15)}$	59
MegSR	5	$18_{(9)}$	$43_{(5)}$	29.00	28.68	$32.59_{(5)}$	$0.290_{(9)}$	$17.70_{(9)}$	$91.72_{(8)}$	$640.63_{(12)}$	64
rainbow	6	$16_{(8)}$	$34_{(3)}$	29.01	28.74	$34.10_{(6)}$	$0.276_{(6)}$	$17.98_{(10)}$	$92.80_{(9)}$	$309.23_{(3)}$	59
VMCL_Taobao	7	$29_{(14)}$	$57_{(11)}$	29.01	28.68	$34.24_{(7)}$	$0.323_{(13)}$	$20.97_{(16)}$	$98.67_{(11)}$	$633.00_{(10)}$	40
Bilibili AI	8	$15_{(7)}$	$41_{(4)}$	29.00	28.70	$34.67_{(8)}$	$0.283_{(8)}$	$17.61_{(7)}$	$90.50_{(7)}$	$633.74_{(11)}$	64
NKU-ESR	9	$12_{(5)}$	$48_{(7)}$	29.00	28.66	$34.81_{(9)}$	$0.276_{(7)}$	$16.73_{(5)}$	$111.12_{(13)}$	$662.51_{(14)}$	65
NJUST_RESTORARION	10	$54_{(27)}$	$89_{(15)}$	28.99	28.68	$35.76_{(10)}$	$0.421_{(28)}$	$27.67_{(26)}$	$108.66_{(12)}$	$643.95_{(13)}$	52
TOVBU	11	$43_{(21)}$	$96_{(19)}$	29.00	28.71	$38.32_{(11)}$	$0.376_{(23)}$	$22.38_{(20)}$	$113.55_{(15)}$	$867.17_{(27)}$	64
Alpan Team	12	$18_{(10)}$	$51_{(9)}$	29.01	28.75	$39.63_{(12)}$	$0.326_{(15)}$	$12.31_{(3)}$	$115.52_{(16)}$	$439.37_{(5)}$	132
Dragon	13	$38_{(19)}$	$70_{(13)}$	29.01	28.69	$41.80_{(13)}$	$0.358_{(20)}$	$21.11_{(18)}$	$120.15_{(17)}$	$260.00_{(2)}$	131
TieGuoDun Team	14	$54_{(27)}$	$104_{(21)}$	28.95	28.65	$42.35_{(14)}$	$0.433_{(29)}$	$27.10_{(25)}$	$112.03_{(14)}$	$788.13_{(22)}$	64
HiImageTeam	15	$7_{(3)}$	$70_{(13)}$	29.00	28.72	$47.75_{(15)}$	$0.242_{(3)}$	$14.51_{(4)}$	$151.36_{(23)}$	$861.84_{(25)}$	100
xilinxSR	16	$66_{(34)}$	$107_{(22)}$	29.05	28.75	$48.20_{(16)}$	$0.790_{(34)}$	$51.76_{(32)}$	$136.31_{(18)}$	$471.37_{(7)}$	38
cipher	17	$50_{(24)}$	$111_{(23)}$	29.00	28.72	$51.42_{(17)}$	$0.407_{(26)}$	$25.25_{(24)}$	$155.35_{(24)}$	$770.82_{(20)}$	67
NJU_MCG	18	$13_{(6)}$	$66_{(12)}$	28.99	28.71	$52.02_{(18)}$	$0.275_{(5)}$	$17.65_{(8)}$	$212.35_{(27)}$	$511.08_{(8)}$	84
IMGWLH	19	$34_{(17)}$	$91_{(17)}$	29.01	28.72	$56.34_{(19)}$	$0.362_{(21)}$	$20.10_{(13)}$	$136.35_{(19)}$	$753.02_{(19)}$	113
imglhl	20	$45_{(22)}$	$92_{(18)}$	29.03	28.75	$56.88_{(20)}$	$0.381_{(24)}$	$23.26_{(21)}$	$144.05_{(21)}$	$451.21_{(6)}$	127
whu_sigma	21	$63_{(32)}$	$132_{(30)}$	29.02	28.73	$61.04_{(21)}$	$0.705_{(33)}$	$43.88_{(30)}$	$142.91_{(20)}$	$1011.54_{(28)}$	64
Aselsan Research	22	$27_{(13)}$	$98_{(20)}$	29.02	28.73	$63.18_{(22)}$	$0.317_{(12)}$	$20.71_{(15)}$	$206.05_{(26)}$	$799.52_{(23)}$	134
Drinktea	23	$59_{(31)}$	$121_{(27)}$	29.00	28.70	$75.52_{(23)}$	$0.589_{(31)}$	$36.92_{(28)}$	$148.05_{(22)}$	$734.54_{(17)}$	67
GDUT_SR	24	$50_{(24)}$	$136_{(31)}$	29.05	28.75	$75.70_{(24)}$	$0.414_{(27)}$	$24.80_{(23)}$	$260.05_{(28)}$	$1457.98_{(34)}$	195
Giantpandacv	25	$63_{(32)}$	$150_{(34)}$	29.07	28.76	$87.87_{(25)}$	$0.683_{(32)}$	$45.07_{(31)}$	$361.23_{(31)}$	$1272.95_{(31)}$	122
neptune	26	$39_{(20)}$	$123_{(29)}$	28.99	28.69	$101.69_{(26)}$	$0.316_{(10)}$	$38.03_{(29)}$	$269.48_{(29)}$	$1179.05_{(29)}$	45
XPixel	27	$3_{(1)}$	$49_{(8)}$	29.01	28.69	$140.47_{(27)}$	$0.156_{(1)}$	$9.50_{(2)}$	$65.76_{(3)}$	$729.94_{(16)}$	43
NJUST_ESR	28	$3_{(1)}$	$89_{(15)}$	28.96	28.68	$164.80_{(28)}$	$0.176_{(2)}$	$8.73_{(1)}$	$160.43_{(25)}$	$1346.74_{(33)}$	25
TeamInception	29	$57_{(30)}$	$146_{(33)}$	29.12	28.82	$171.56_{(29)}$	$0.505_{(30)}$	$32.42_{(27)}$	$502.27_{(34)}$	$866.16_{(26)}$	74
cceNBgdd	30	$33_{(16)}$	$114_{(24)}$	28.97	28.67	$180.60_{(30)}$	$0.339_{(16)}$	$21.11_{(17)}$	$404.16_{(33)}$	$739.65_{(18)}$	197
ZLZ	31	$55_{(29)}$	$118_{(26)}$	29.00	28.72	$183.43_{(31)}$	$0.372_{(22)}$	$64.45_{(33)}$	$57.51_{(2)}$	$1244.23_{(30)}$	16
Express	32	$31_{(15)}$	$117_{(25)}$	29.04	28.77	$203.16_{(32)}$	$0.339_{(17)}$	$20.41_{(14)}$	$325.53_{(30)}$	$853.27_{(24)}$	148
Just Try	33	$70_{(35)}$	$170_{(35)}$	29.12	28.81	$247.90_{(33)}$	$0.832_{(35)}$	$135.30_{(35)}$	$392.43_{(32)}$	$2387.93_{(35)}$	207
ncepu_explorers	34	$47_{(23)}$	$137_{(32)}$	29.09	28.79	$317.66_{(34)}$	$0.390_{(25)}$	$23.73_{(22)}$	$994.25_{(35)}$	$771.54_{(21)}$	374
mju_mnu	35	$53_{(26)}$	$121_{(27)}$	29.06	28.79	$332.28_{(35)}$	$0.345_{(19)}$	$78.81_{(34)}$	$46.76_{(1)}$	$1310.72_{(32)}$	40

Main Track: Runtime Track

1st ByteESR team, 2nd NJU Jet team, 3rd NEESR team

The average runtime of the first three solutions is below 30 ms. The first 12 teams proposed a solution with average runtime lower than 40 ms.

Sub-Track 1: Model Complexity Track

1st Xpixel team and NJUST ESR team, 3rd HiImageTeam

The solution proposed by XPixel team has slightly fewer parameters while the solution proposed by NJUST ESR team has fewer computation.

Sub-Track 2: Overall Performance

1st NEESR team, 2nd ByteESR team, 3rd rainbow team

The xilinxSR team achieved the best PSNR fidelity metric (29.05dB on the validation set and 29.75dB on test set) among the solutions that outperforms the baseline network IMDN in terms of runtime and number of parameters.

Architectures and Ideas

1. Modifying the architecture of information multi-distillation block (IMDB) and residual feature distillation block (RFDB) is the mainstream technique.
2. Multi-stage information distillation might influence the inference speed of the super efficient models.
3. Reparameterization could bring slight performance improvement.
4. Filter decomposition methods could effectively reduce the model complexity.
5. Network pruning began to play a role.
6. Activation function is an important factor.
7. Design of loss functions is also among the consideration.
8. Advanced training strategy guarantees the performance of the network.

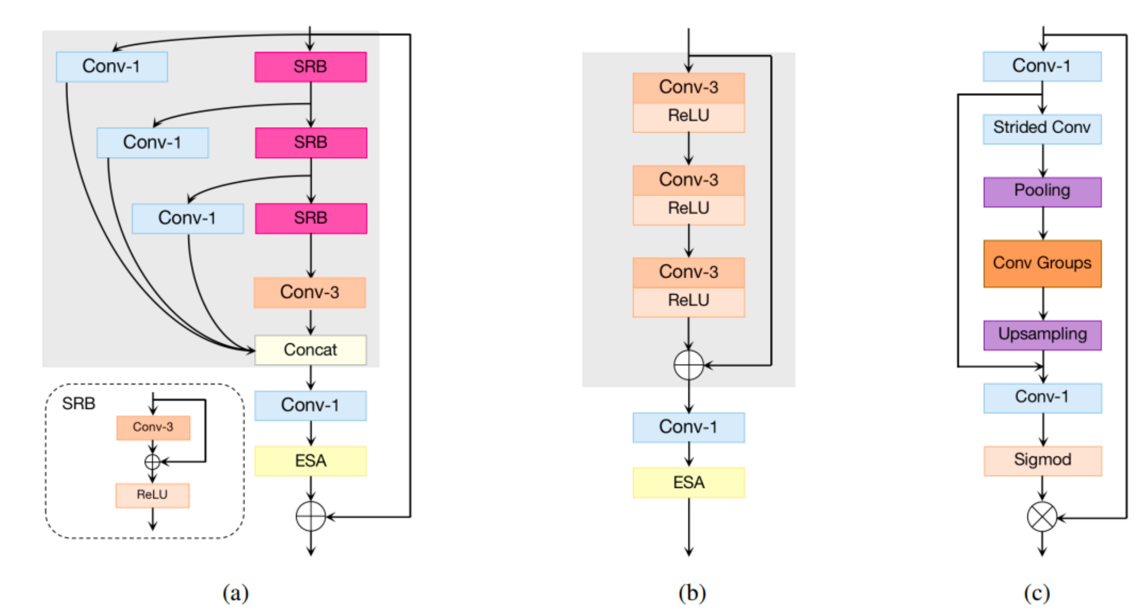


Figure 2. *ByteESR Team:* (a) Residual feature distillation block (RFDB). (b) Residual local feature block (RLFB). (c) Enhanced Spatial Attention (ESA).

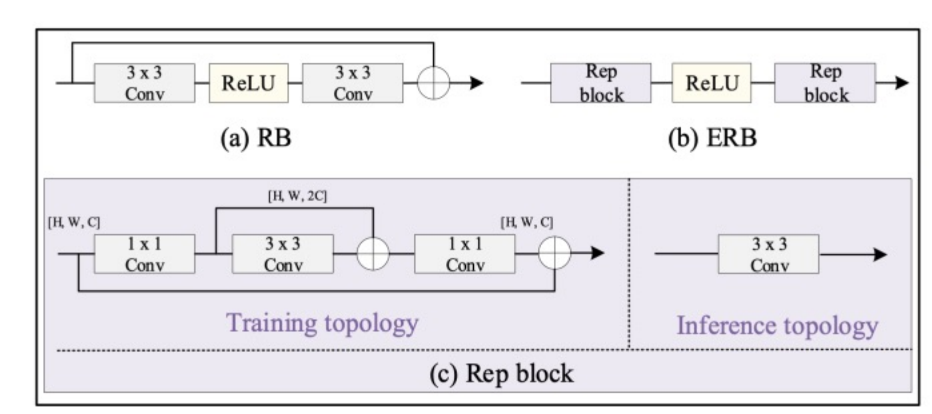


Figure 5. *NJU_Jet Team:* Comparison between a normal residual block (RB) [48] and an enhanced residual block (ERB).

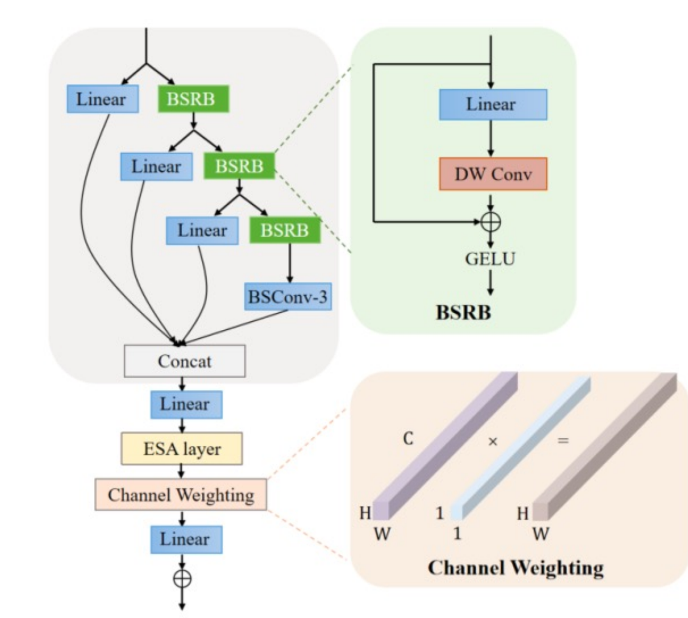


Figure 9. *XPixel Team:* The architecture of the proposed efficient separable residual blocks (ESDB).

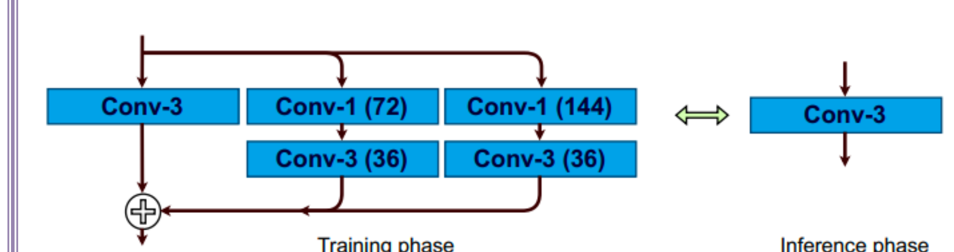


Figure 13. *rainbow Team:* A schematic diagram of structural re-parameterization strategy.