Space-Time-Aware Multi-Resolution Video Enhancement

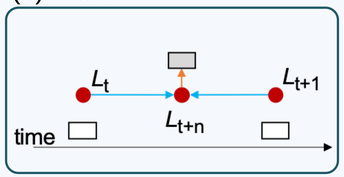
Muhammad Haris, Gregory Shakhnarovich, Norimichi Ukita

TOYOTA TECHNOLOGICAL INSTITUTE AT CHICAGO

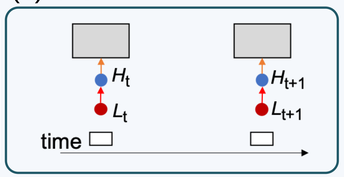
CVPR SEATTLE WASHINGTON JUNE 16-18 2020

Existing Networks

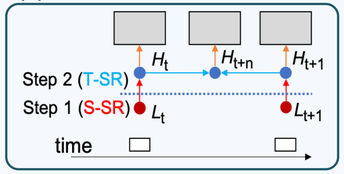
(a) T-SR



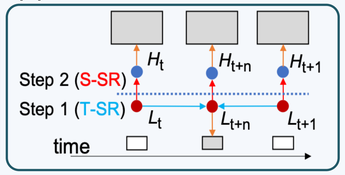
(b) S-SR



(c) S-SR → T-SR



(d) T-SR → S-SR



Our Contributions

(1) The novel learning-based ST-SR method
(2) Joint learning on multiple resolutions to estimate both large and subtle motions observed in videos
(3) A novel view of S-SR and T-SR that are superior to direct S-SR and T-SR

Ablation Studies

Baseline comparison of STAR

Method	I_t^{sr} PSNR	I_t^{sr} SSIM	I_{t+}^{sr} PSNR	I_{t+}^{sr} SSIM
STAR w/o Stage 2	30.920	0.921	30.002	0.917
STAR w/o Flow	31.489	0.928	30.086	0.918
STAR w/o FR	31.601	0.929	30.229	0.920
STAR	31.920	0.933	30.365	0.923

Analysis on Multi-Resolution ST-SR

Method	I_t^{sr} PSNR	I_t^{sr} SSIM	I_{t+}^{sr} PSNR	I_{t+}^{sr} SSIM
(1) Only ST-SR	32.349	0.938	30.704	0.928
(2) ST-SR+T-SR$_{S-HR}$	32.398	0.939	30.712	0.928
(3) ST-SR+T-SR$_{S-LR}$	32.421	0.939	30.760	0.928
(4) Full	32.547	0.940	30.830	0.929

Analysis on different training objectives

Method	I_t^{sr} PSNR	I_t^{sr} SSIM	I_{t+}^{sr} PSNR	I_{t+}^{sr} SSIM	I_{t+}^{s} PSNR	I_{t+}^{s} SSIM
STAR	31.601	0.929	30.229	0.920	39.014	0.990
STAR-ST	31.883	0.933	30.350	0.928	NA	NA
STAR-S	32.026	0.935	NA	NA	NA	NA
STAR-T	NA	NA	NA	NA	39.028	0.990

Analysis on different training losses

Loss	I_t^{sr} PSNR	I_t^{sr} SSIM	I_t^{sr} NIQE [38]	I_{t+}^{sr} PSNR	I_{t+}^{sr} SSIM	I_{t+}^{sr} NIQE [38]
L_f	32.153	0.936	6.288	30.545	0.925	6.289
L_r	32.349	0.938	6.905	30.704	0.928	6.942

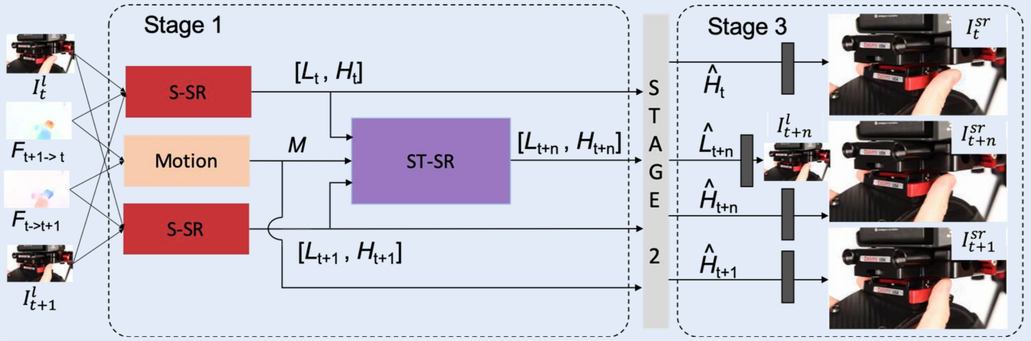
Analysis on larger temporal scale (4x)

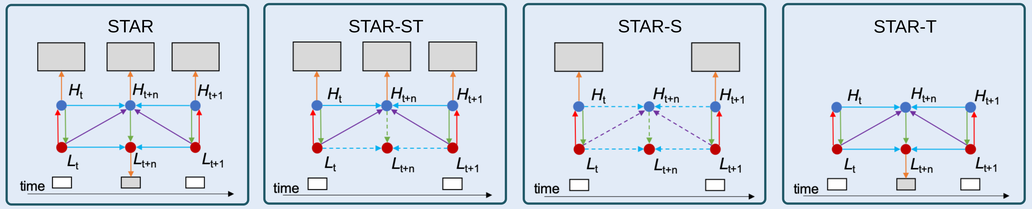
Method	I_t^{sr} PSNR	I_t^{sr} SSIM	I_{t+}^{sr} PSNR	I_{t+}^{sr} SSIM
(1) STAR-ST → STAR-ST	33.007	0.941	27.186	0.893
(2) STAR-ST → STAR-T	34.146	0.950	27.640	0.901

Contact
TTI, Japan
Intelligent Information Media Lab
Muhammad Haris
Muhammad.haris@bukalapak.com

SCAN ME

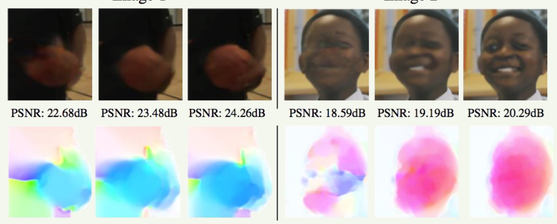
Our Proposed Network



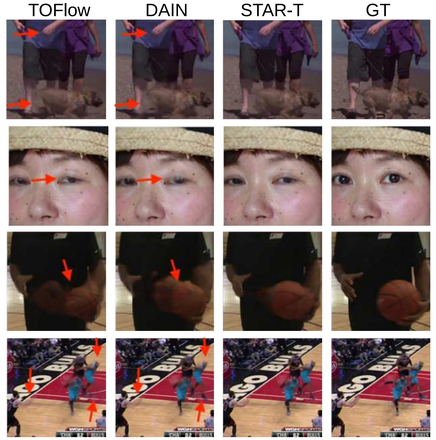


Video results on ST-SR

The effect of Flow Refinement module



Visual results on T-SR



Experimental Results

Qualitative evaluation for ST-SR

Method	UCF101 [53] PSNR	UCF101 [53] SSIM	UCF101 [53] NIQE	Vimeo90K [58] PSNR	Vimeo90K [58] SSIM	Vimeo90K [58] NIQE	Middlebury (Other) [2] PSNR	Middlebury (Other) [2] SSIM	Middlebury (Other) [2] NIQE
TOFlow [58] → DBPN [16]	27.228	0.885	9.123	28.821	0.897	7.758	24.984	0.790	6.473
DBPN [16] → TOFlow [58]	28.112	0.902	8.630	29.867	0.915	7.120	26.012	0.808	5.801
DBPN [16] → DAIN [3]	28.175	0.902	8.755	30.021	0.918	7.223	26.268	0.809	5.869
DBPN-MI → DAIN [3]	28.578	0.916	8.922	30.286	0.923	7.218	26.447	0.815	5.702
DAIN [3] → RBPN [17]	27.631	0.909	8.932	29.422	0.916	7.253	25.744	0.811	5.814
RBPN [17] → DAIN [3]	28.729	0.919	8.769	30.455	0.926	7.081	26.766	0.821	5.522
*RBPN [17] → DAIN [3]	28.856	0.920	8.799	30.623	0.927	7.183	26.923	0.823	5.444
STAR-L_f	28.829	0.920	7.875	30.608	0.926	6.251	26.881	0.824	4.579
STAR-ST-L_f	28.806	0.920	7.868	30.714	0.927	6.470	27.020	0.826	4.802
STAR-ST-L_r	29.111	0.924	8.787	30.830	0.929	7.154	27.115	0.827	5.423

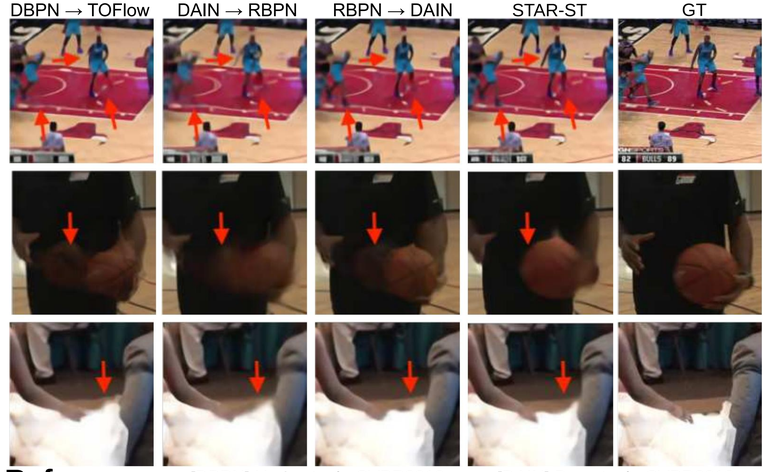
Qualitative evaluation for S-SR

Method	UCF101 PSNR	UCF101 SSIM	Vimeo90K PSNR	Vimeo90K SSIM
Bicubic	27.217	0.887	28.134	0.878
DBPN [16]	29.828	0.913	31.505	0.927
DBPN-MI	30.666	0.934	31.835	0.933
RBPN [17]	30.969	0.938	32.154	0.936
STAR-ST	31.532	0.942	32.547	0.940
STAR-S	31.604	0.943	32.702	0.941

Qualitative evaluation for T-SR

Method	UCF101 [53] PSNR	UCF101 [53] SSIM	Vimeo90K [58] PSNR	Vimeo90K [58] SSIM	Middlebury [2] Other IE	Middlebury [2] *Eval IE
SPyNet [44]	33.67	0.963	31.95	0.960	2.49	-
EpicFlow [45]	33.71	0.963	32.02	0.962	2.47	-
MIND [36]	33.93	0.966	33.50	0.943	3.35	-
DVF [35]	34.12	0.963	31.54	0.946	7.75	-
TOFlow [58]	34.58	0.967	33.73	0.968	2.51	5.49
SepConv-L_f [42]	34.69	0.965	33.45	0.967	2.44	-
SepConv-L_1 [42]	34.78	0.967	33.79	0.970	2.27	5.61
MEMC-Net [4]	34.96	0.968	34.29	0.974	2.12	4.99
DAIN [3]	34.99	0.968	34.71	0.976	2.04	4.86
STAR	34.78	0.964	33.11	0.957	2.41	-
STAR-T$_{LR}$	34.80	0.964	33.19	0.958	2.36	-
STAR-T$_{HR}$	35.07	0.967	35.11	0.976	1.95	4.70

Visual results on ST-SR



References

[DBPN] Haris et. al., CVPR2018
[TOFLOW] Xue et. al., IJCV2019
[DAIN] Bao et. al., CVPR2019
[RBPN] Haris et. al., CVPR2019