Super Resolution on Resource Constrained Devices

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Collabora

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Outline

1. Principle Super-Resolution
2. Contributions of Blind Super-Resolution
3. Overall Scheme
4. Network Architecture
5. Experimental Results
6. Visual Comparison for Different Types of Images

What is Super-Resolution?

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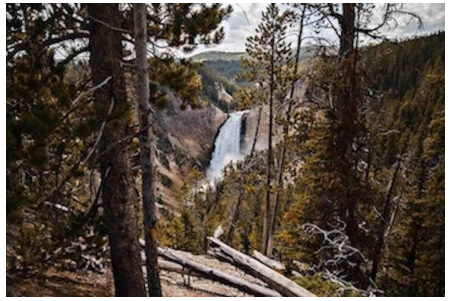
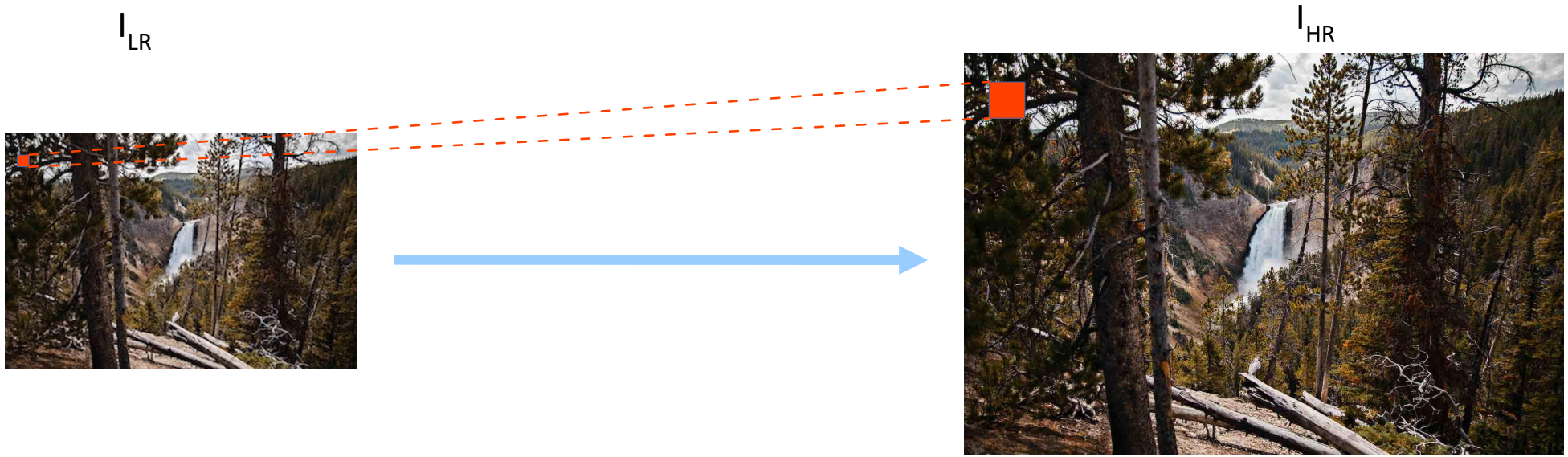
What is Super Resolution?

I_{LR}



I_{HR}

What is Super Resolution?



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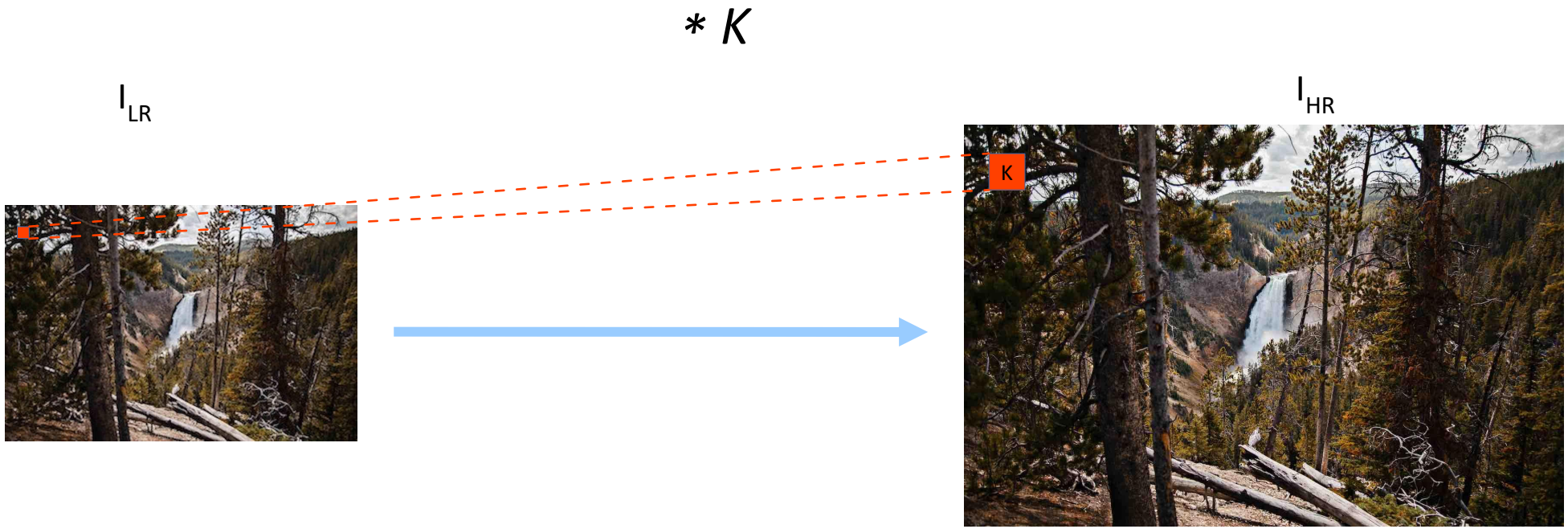

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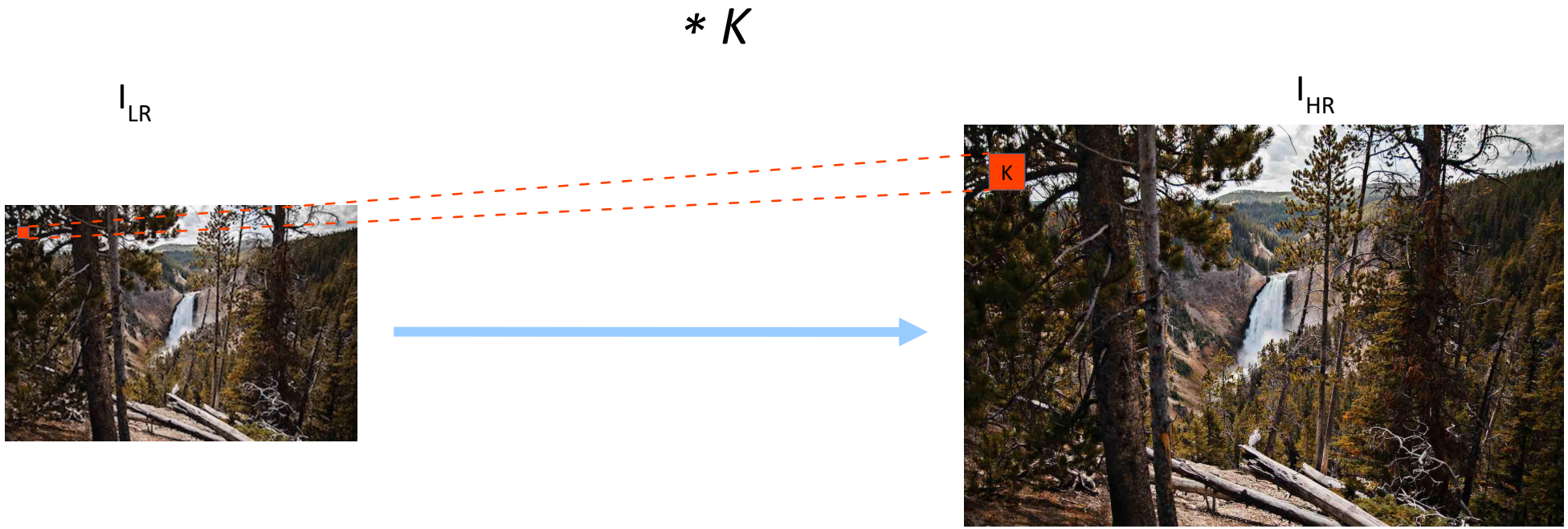

Current leading Super-Resolution methods → Deep Learning based

EDSR B. Lim et al. 2017, **RDN** Y. Zhang et al. , 2018, **SAN** T. Dai et al. 2019

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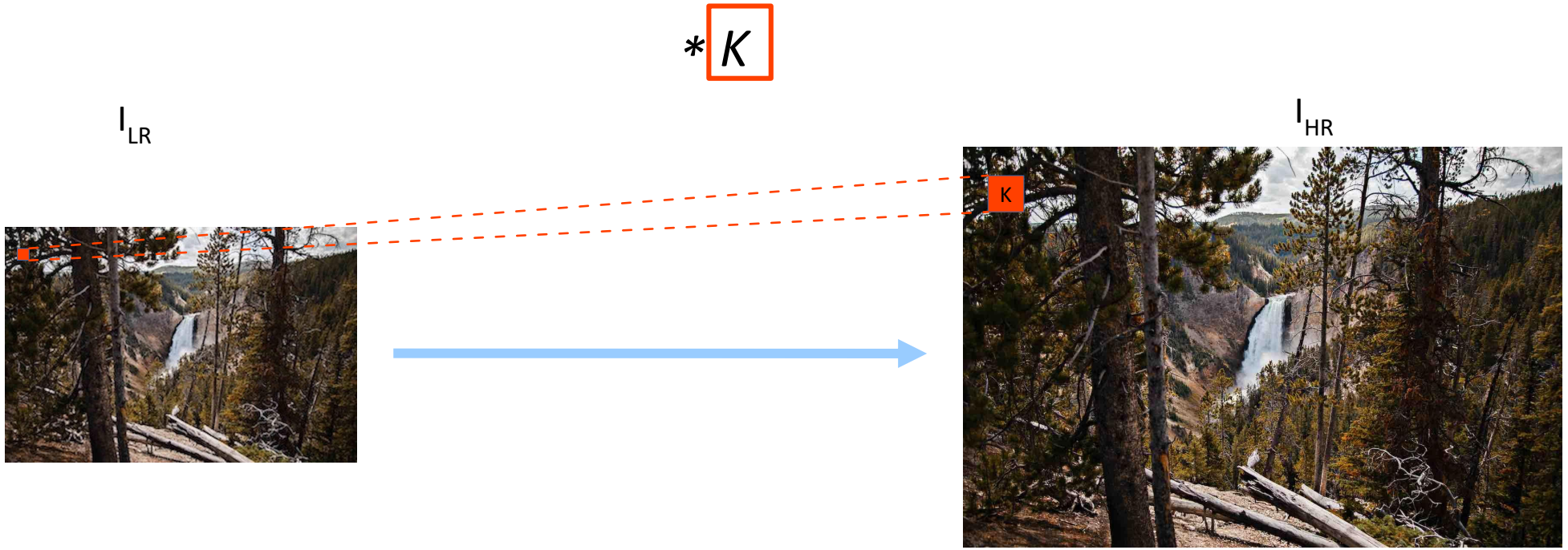

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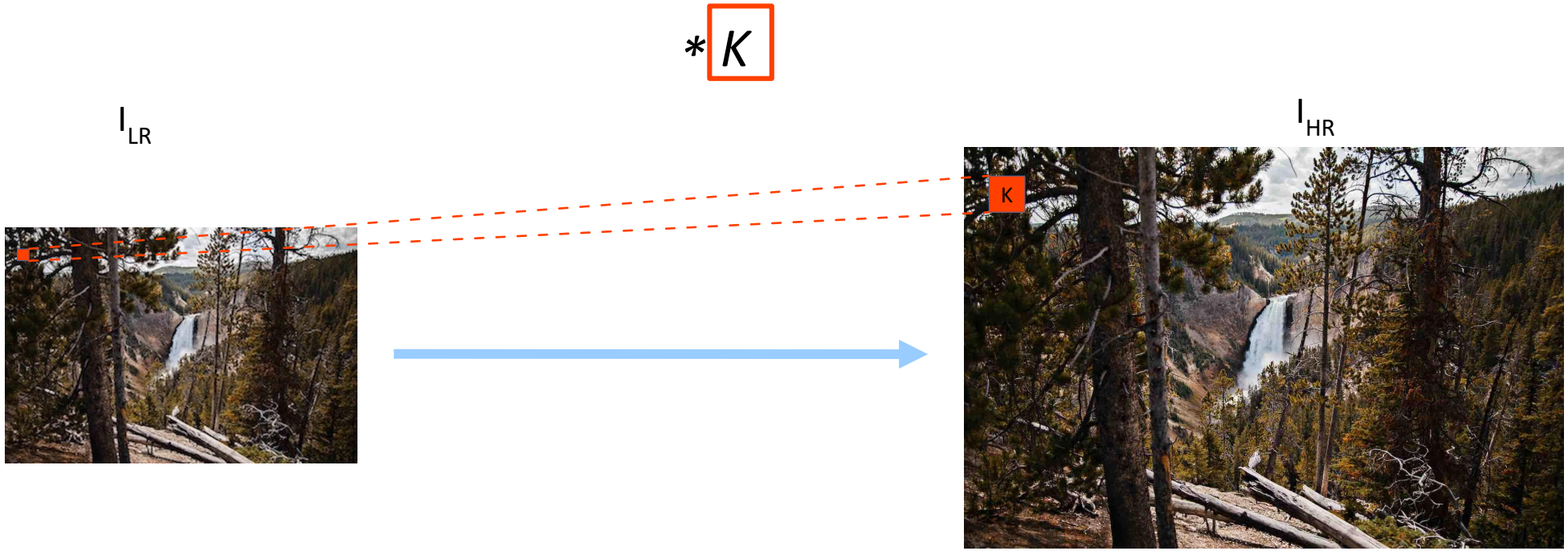

Current leading Super-Resolution methods → Deep Learning based

Performs poorly when the wrong kernel is used

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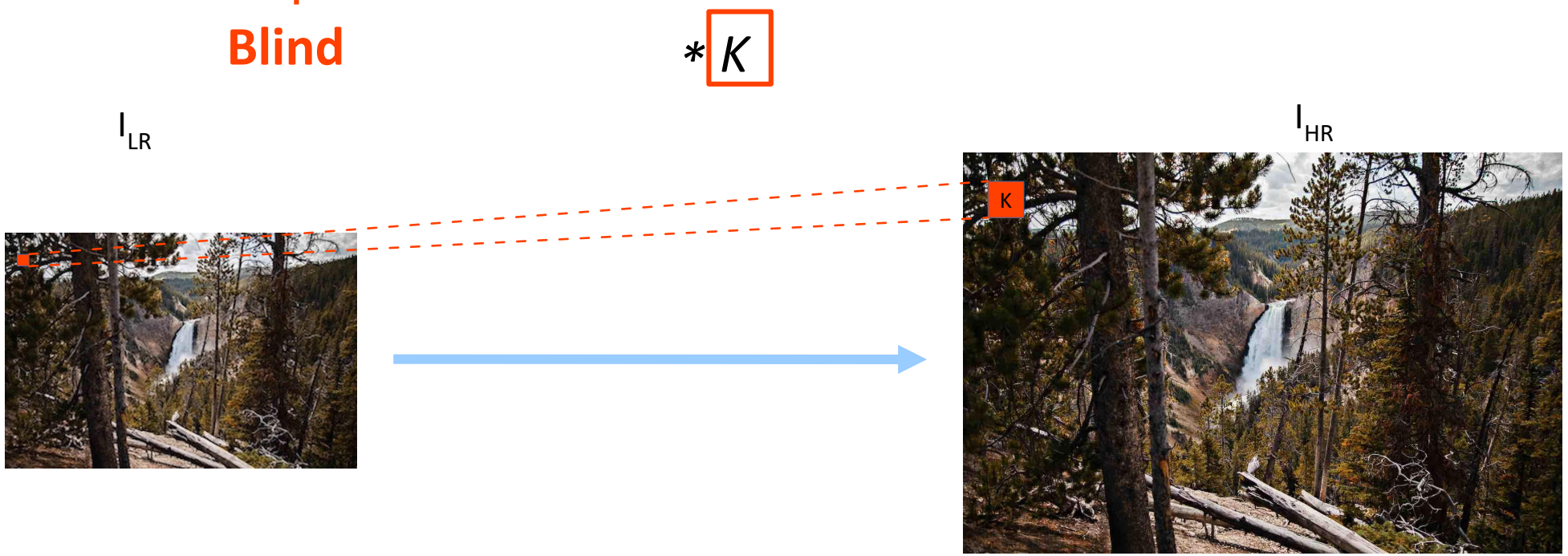

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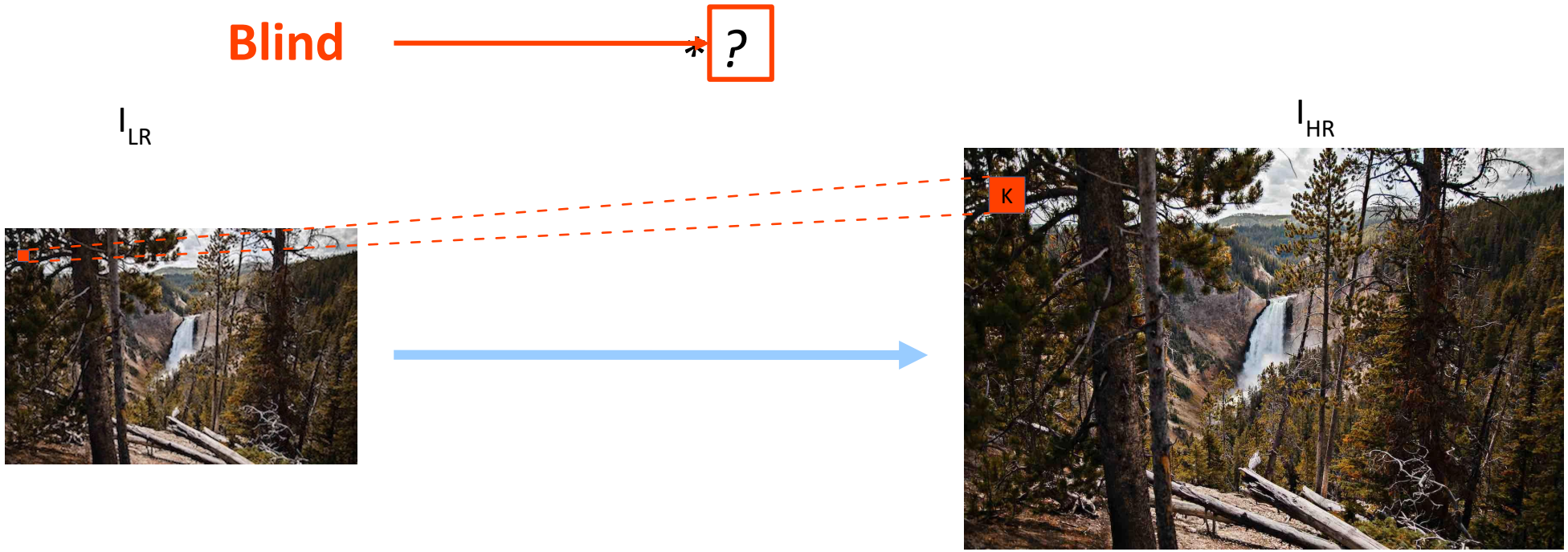

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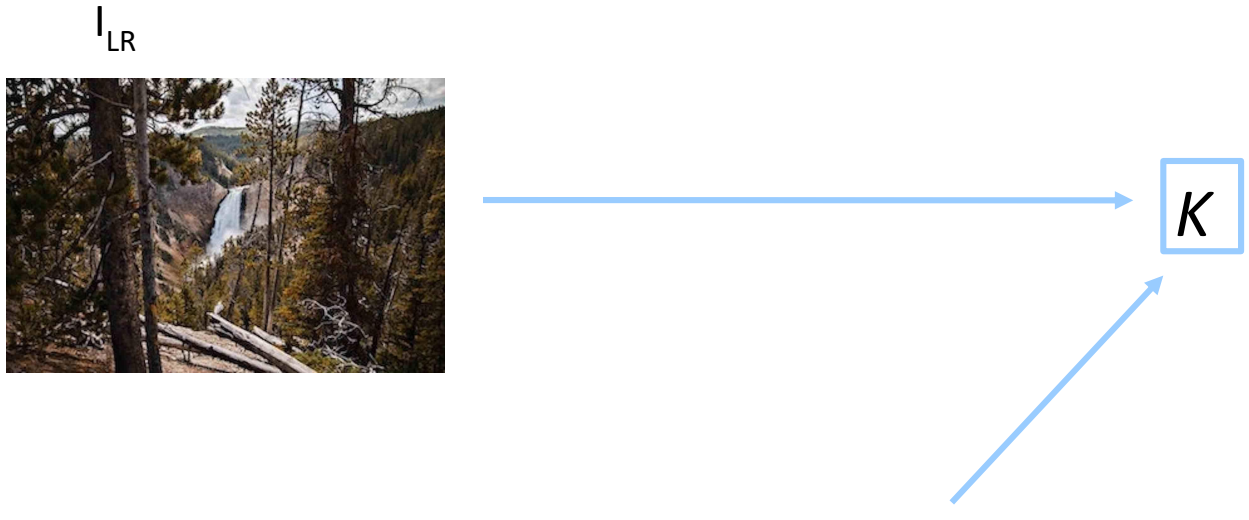
Blind Super Resolution?



- Estimate the image specific SR-kernel
- Fully unsupervised, no labeled training data needed.

Blind Super Resolution → State-of-The-Art Super Resolution results in the wild

The Problem with existing SR methods.

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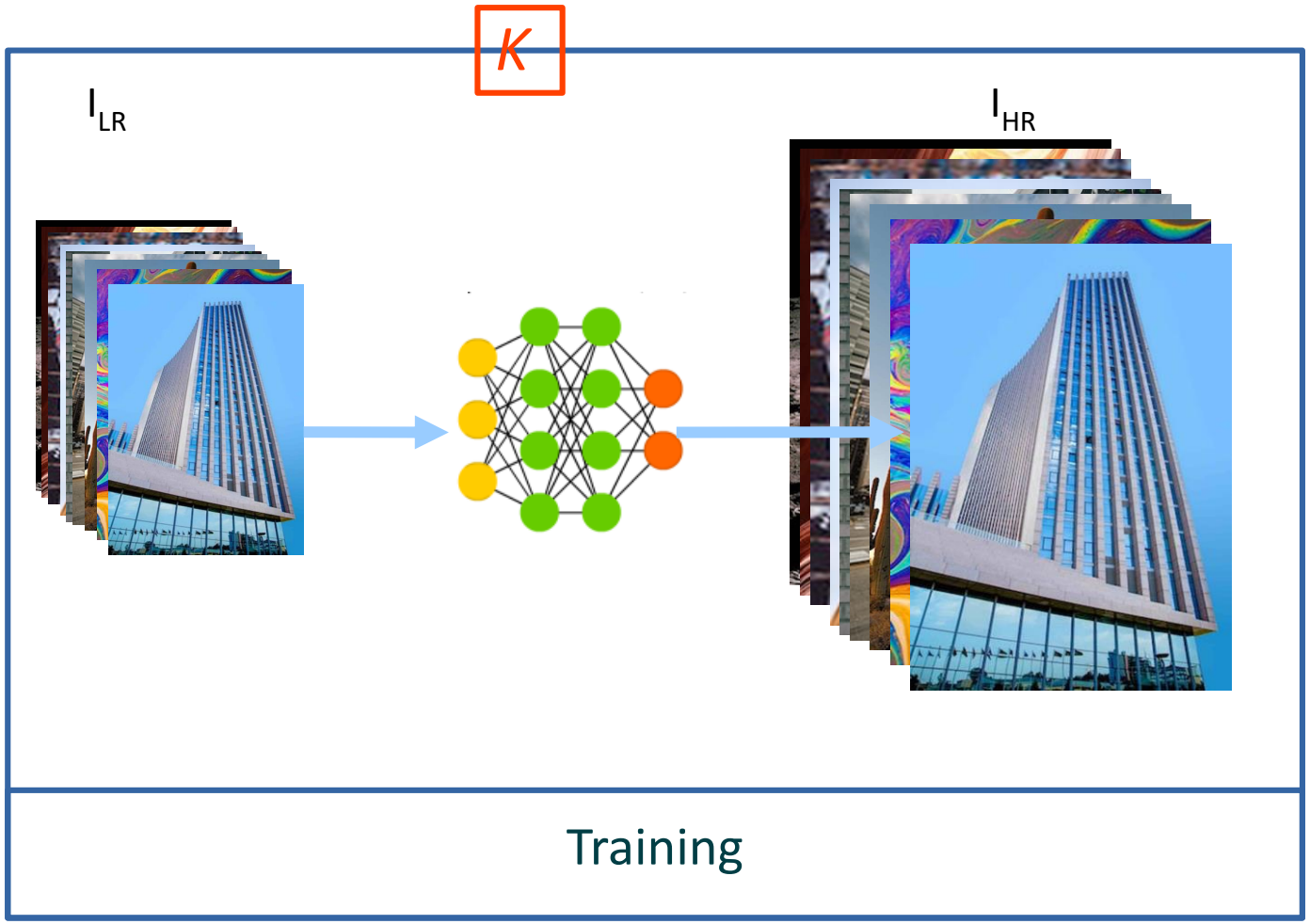
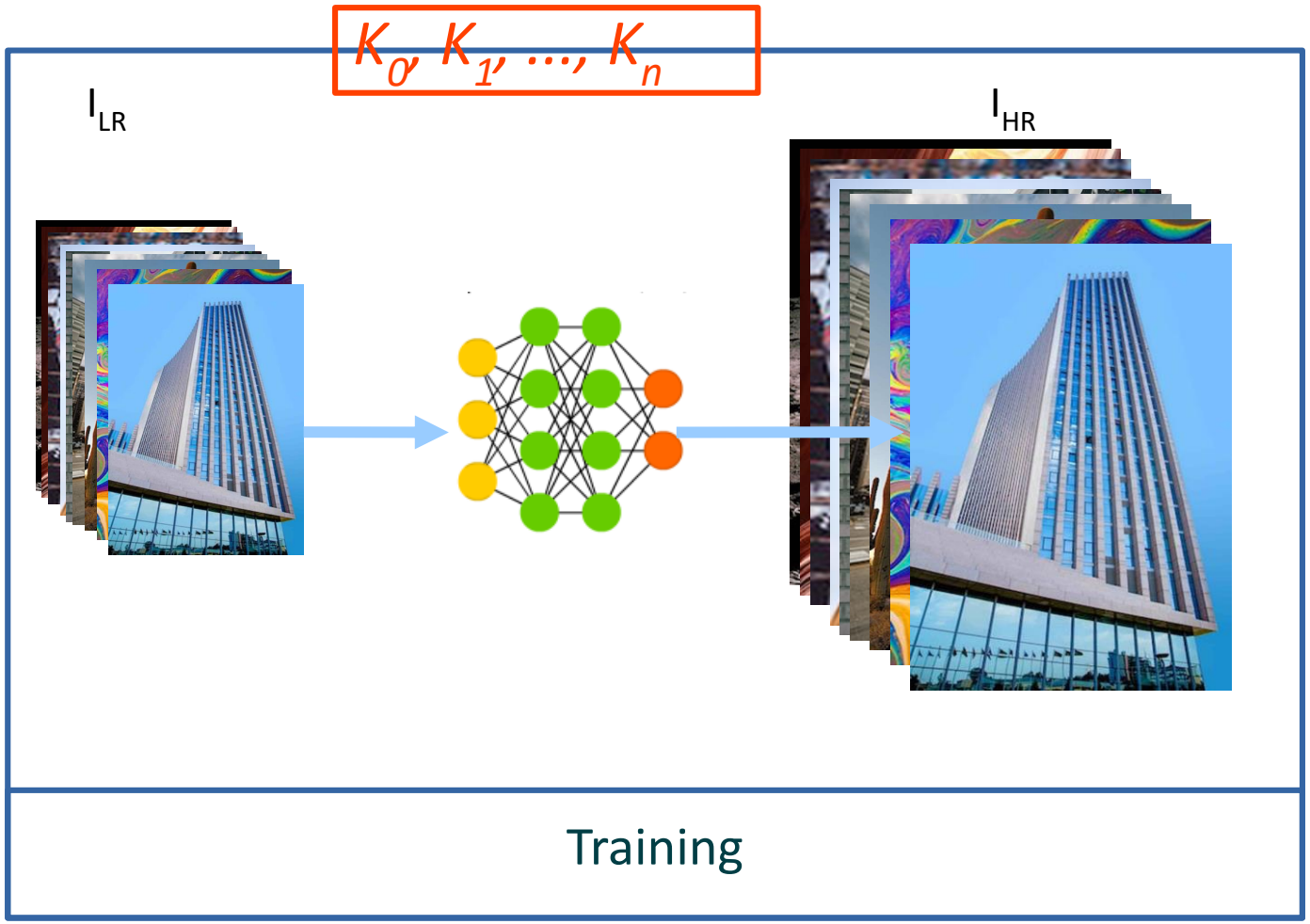
Super Resolution types



Super Resolution types

1. Implicitly assume ***K***
   - **EDSR** B. Lim et al. 2017

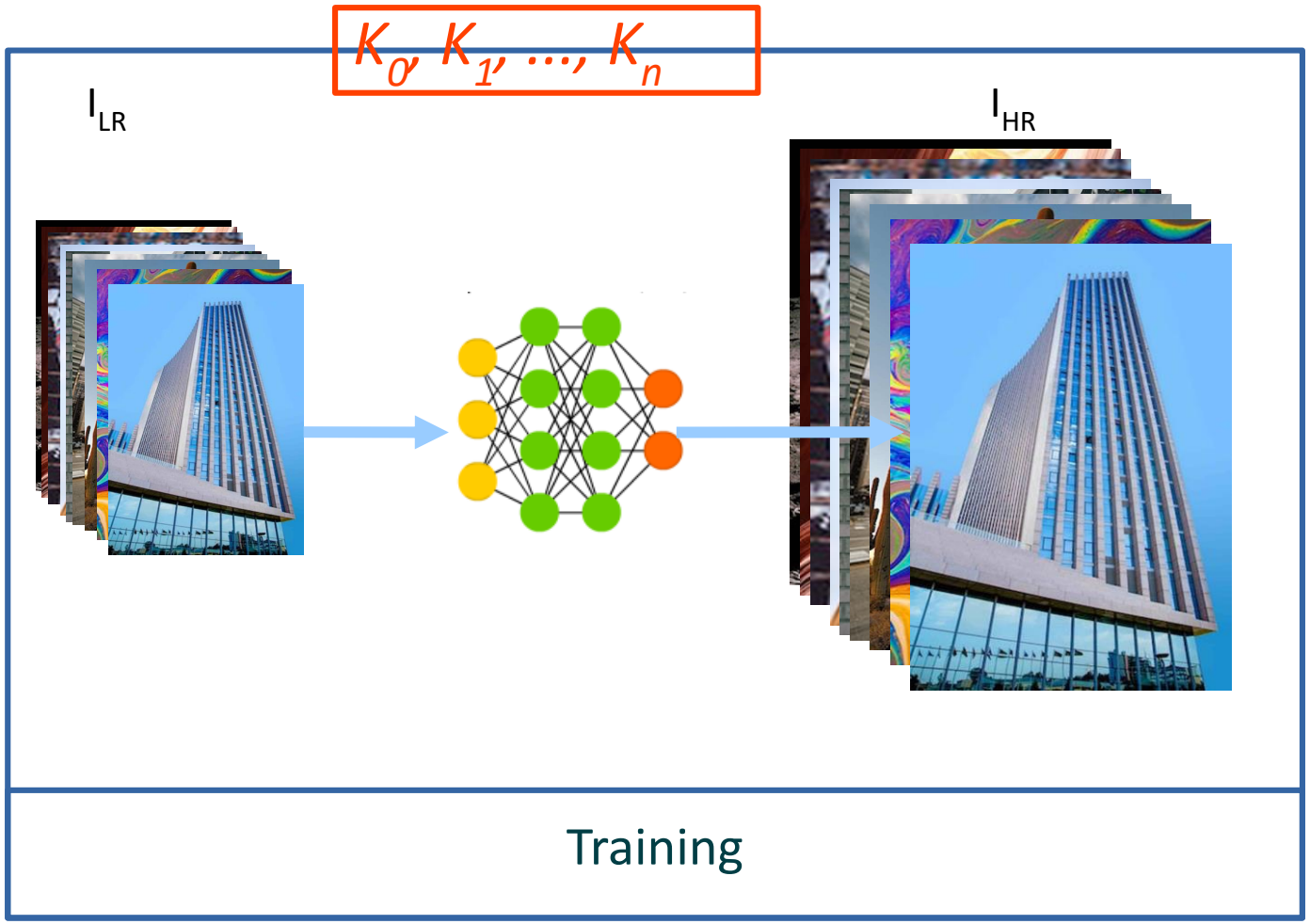
Super Resolution types



Super Resolution types

1. Implicitly assume ***K***
   - **EDSR** B. Lim et al. 2017
1. Agnostic to ***K***
   - **WDSR** J. Yu et al. 2020

Super Resolution types



Super Resolution types

1. Implicitly assume ***K***
   - **EDSR** B. Lim et al. 2017
1. Agnostic to ***K***
   - **WDSR** J. Yu et al. 2020
1. Take predefined ***K*** *(estimation)* as input
   - **ZSSR** A. Shocher et al. 2017

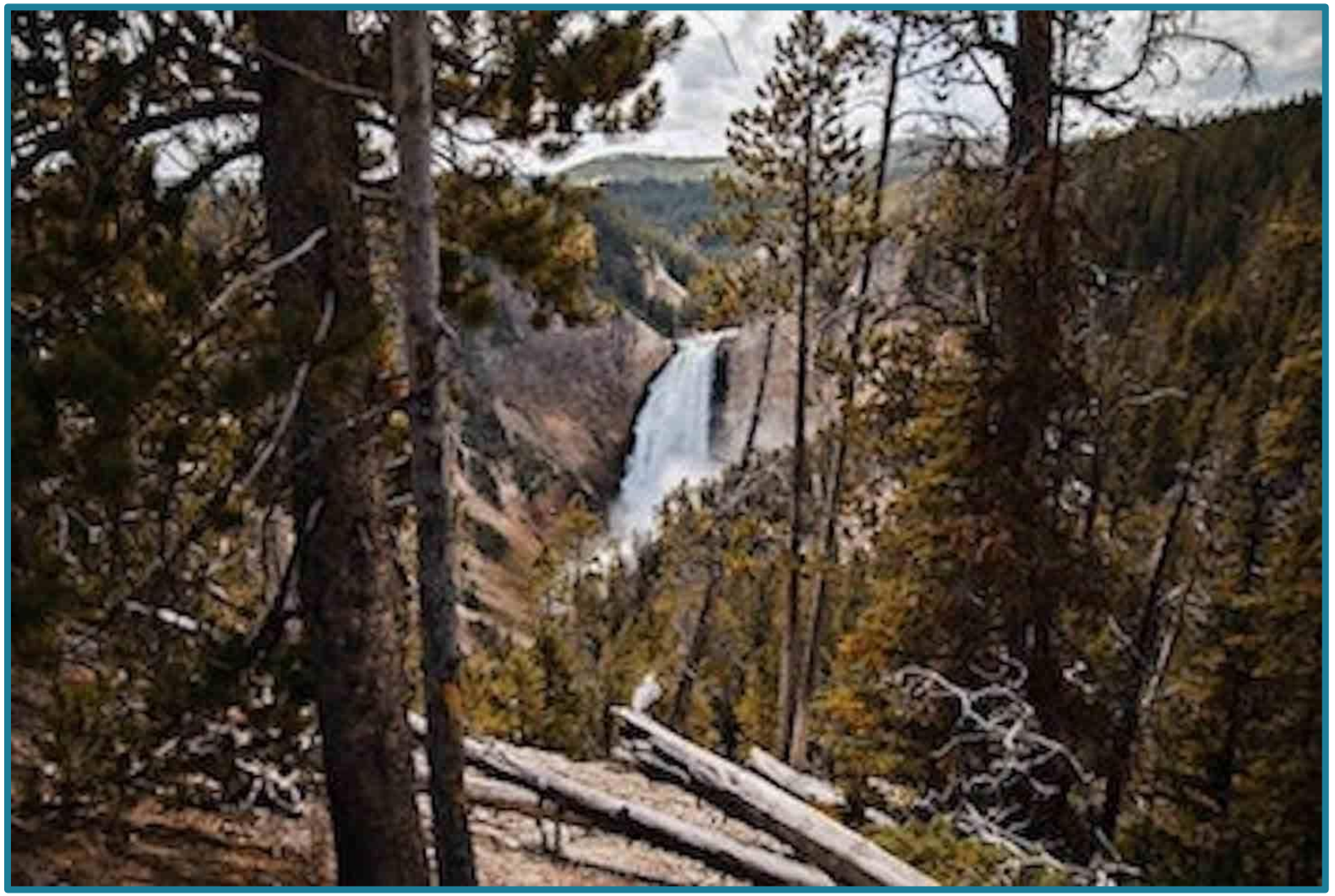
Super Resolution

Fixed known **K**

Super Resolution

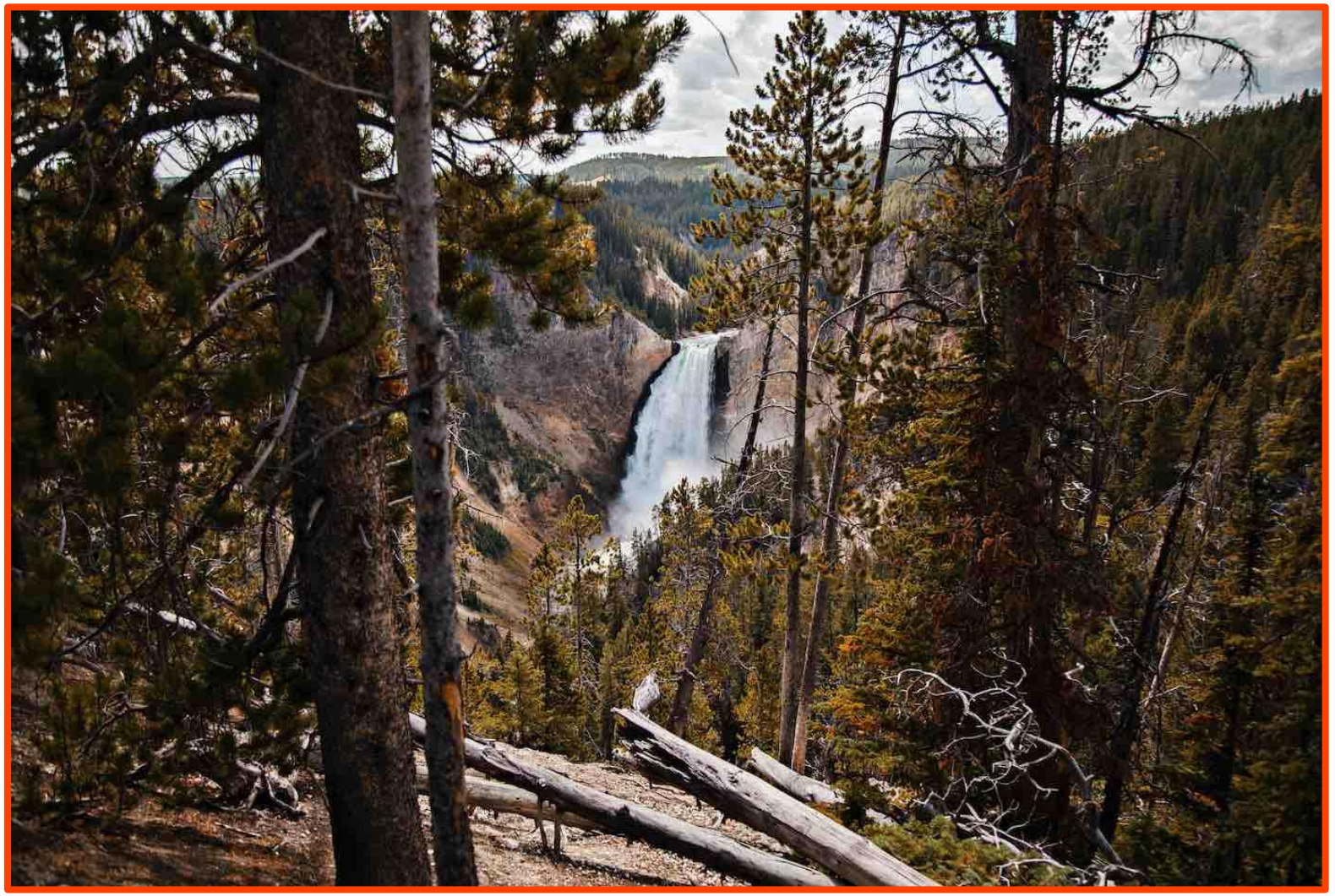
2021 embedded VISION summit

Bicubic interpolation



Super Resolution

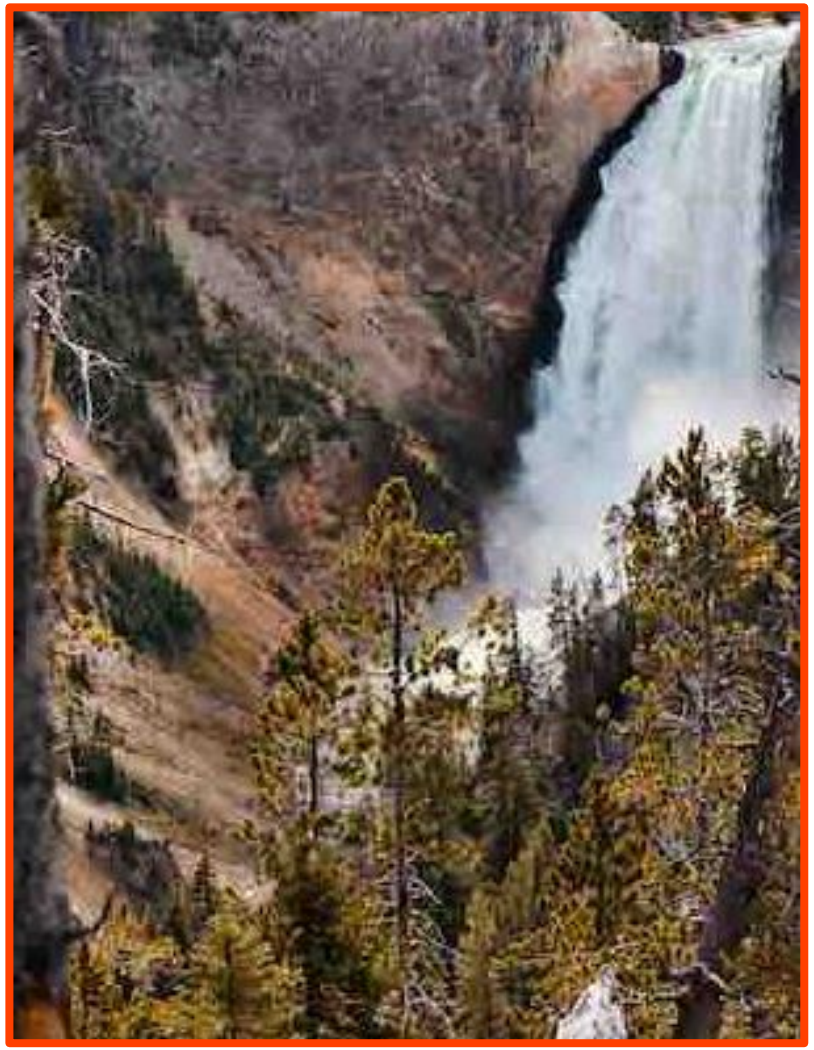
Super Resolution



Super Resolution

Bicubic interpolation

Super Resolution

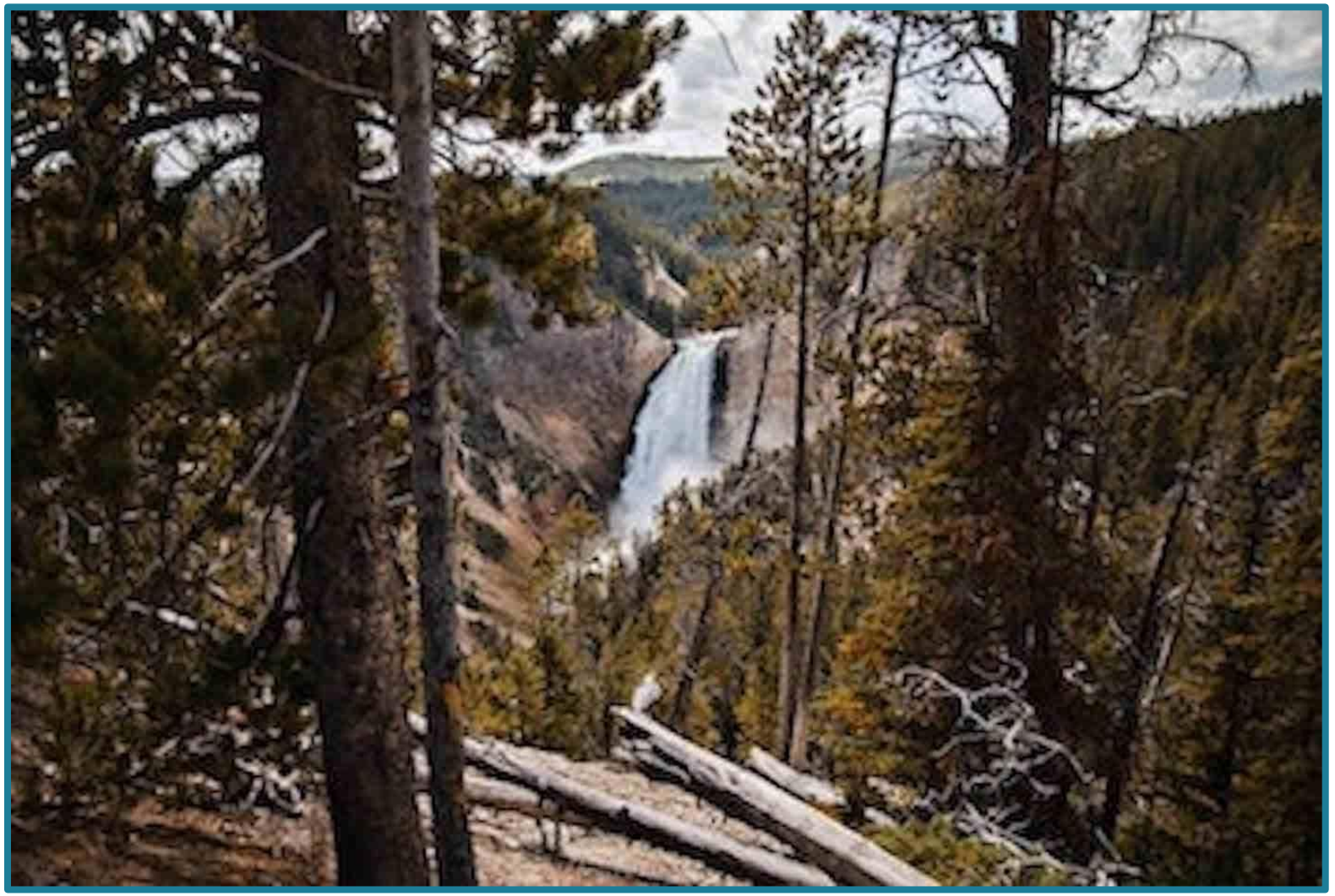


Super Resolution

Fixed unknown **K**

Super Resolution

Bicubic interpolation



Super Resolution

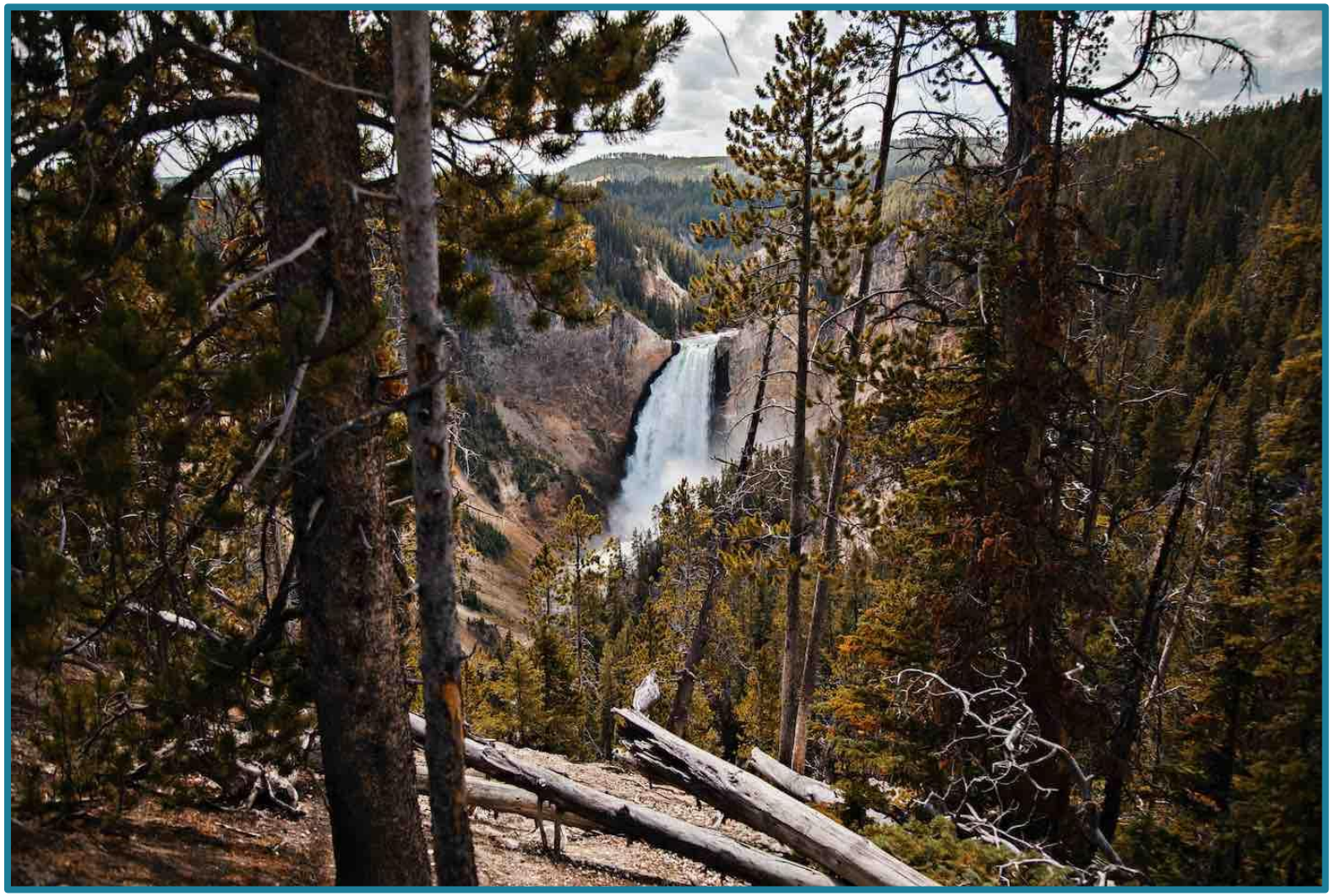
Super Resolution

assuming fixed kernel

Super Resolution

Super Resolution

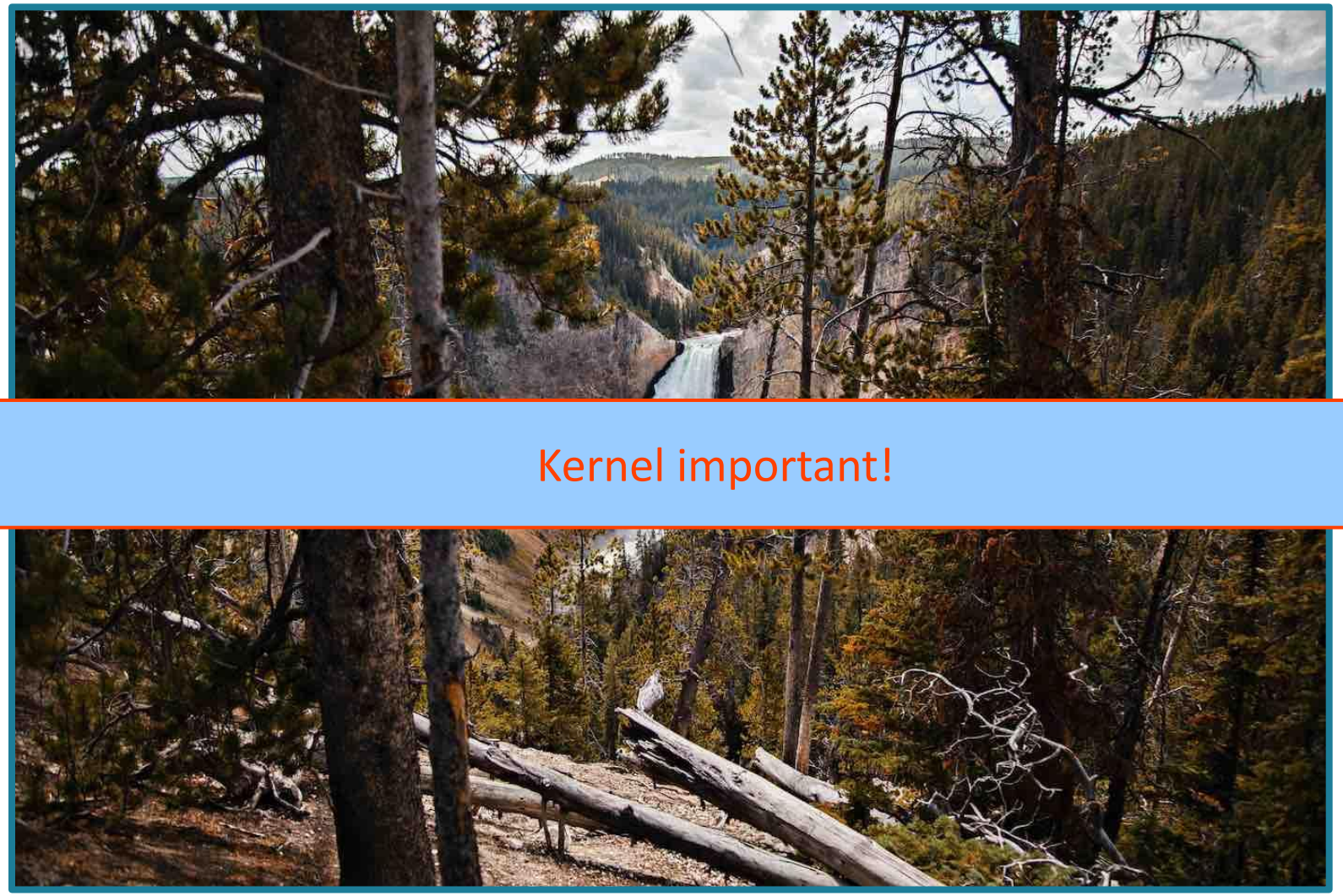
image specific kernel



Super Resolution

Super Resolution

image specific kernel



Kernel important!

Kernel Estimation

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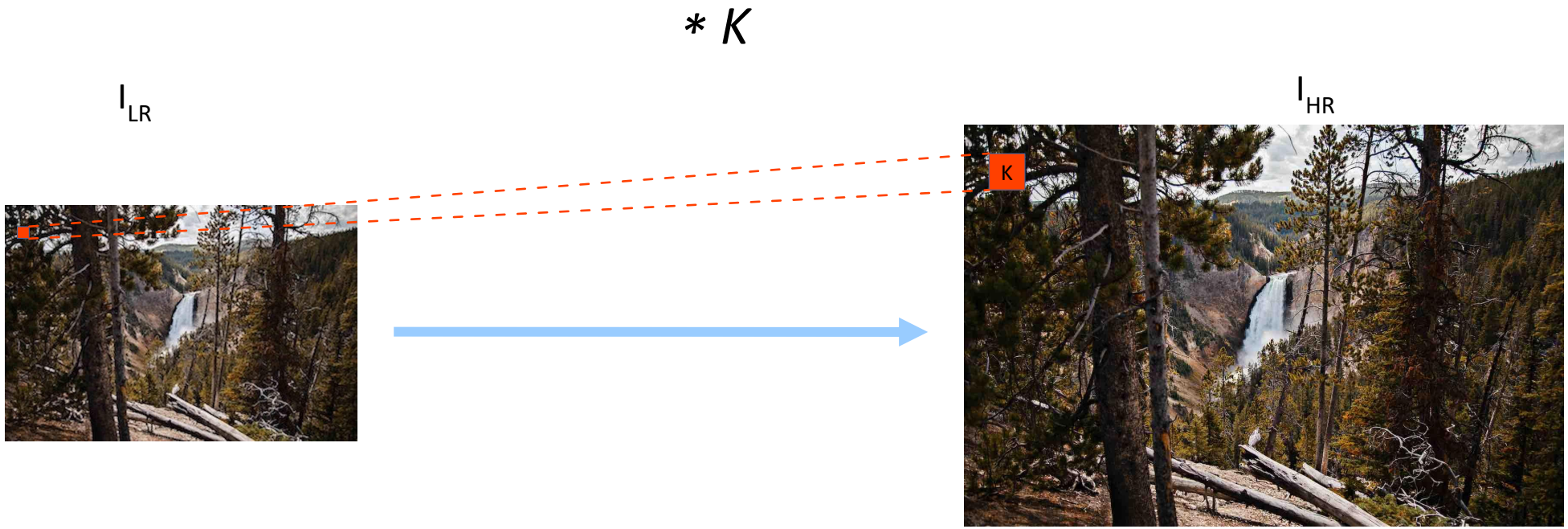
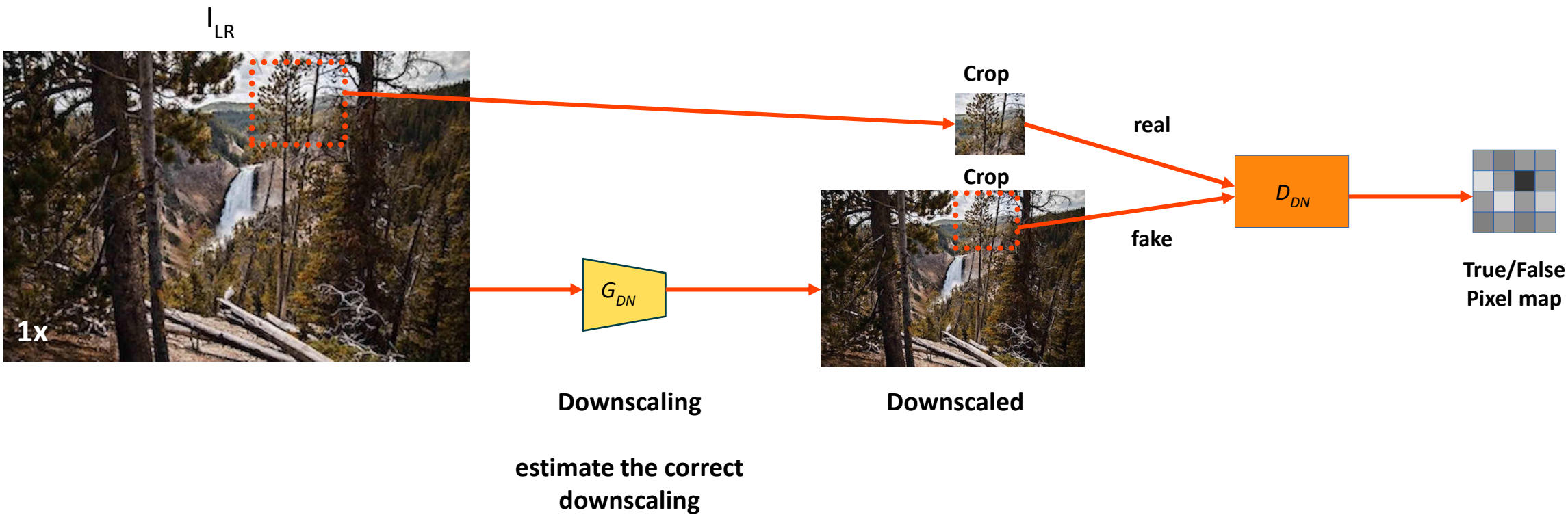
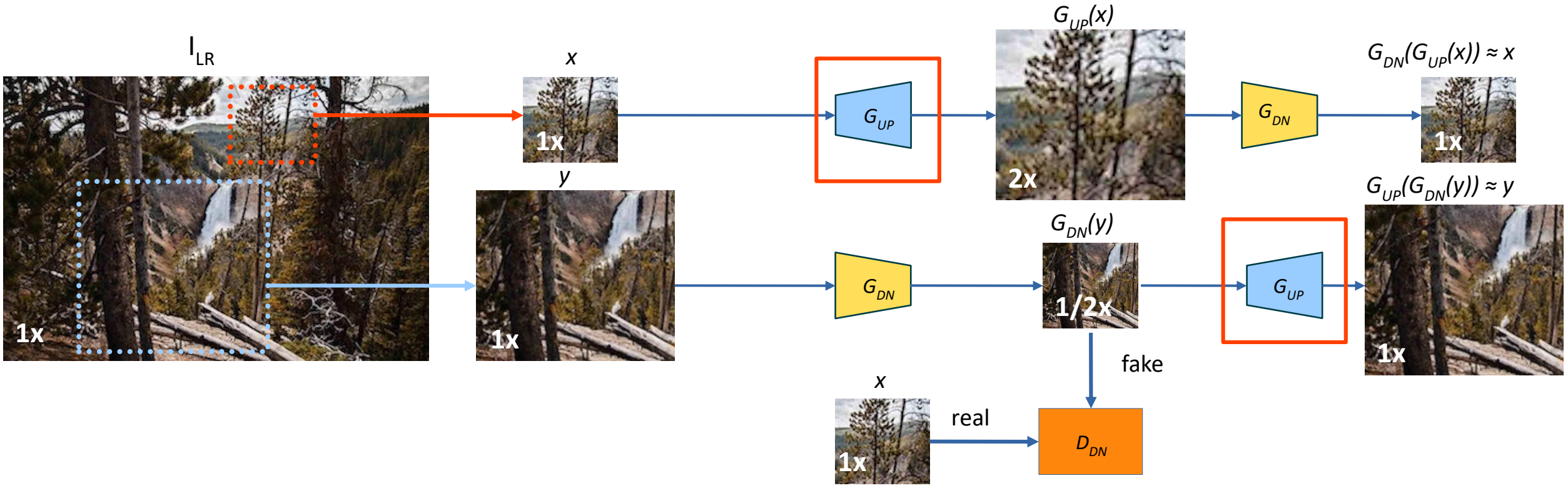
What is Super Resolution?



Internal KernalGAN



Network Architecture



Network Architecture

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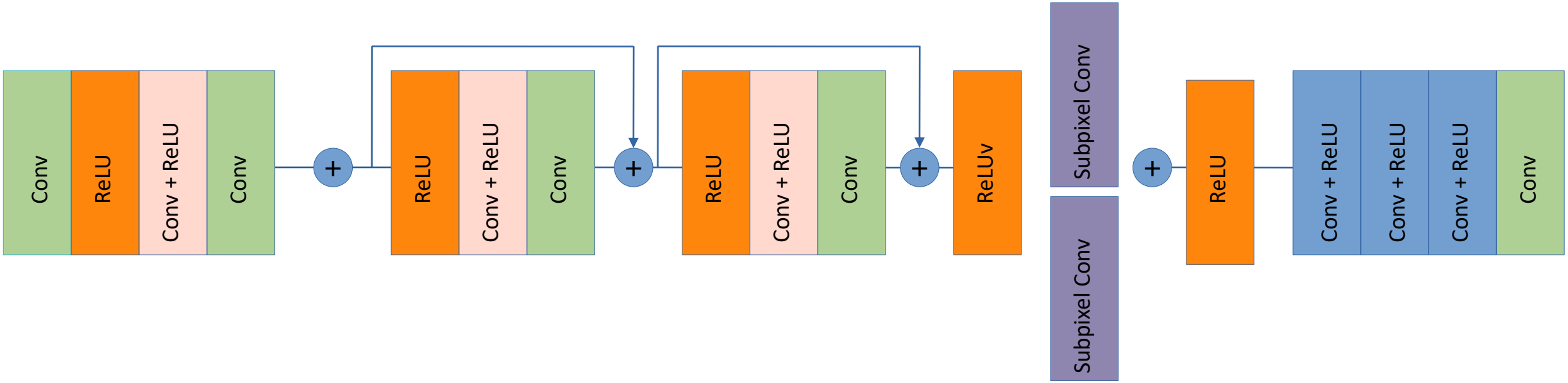
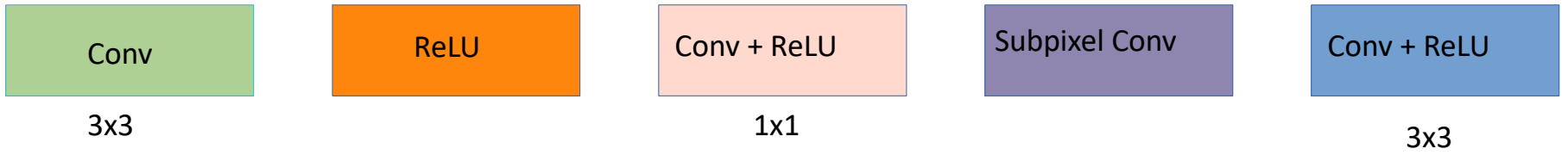
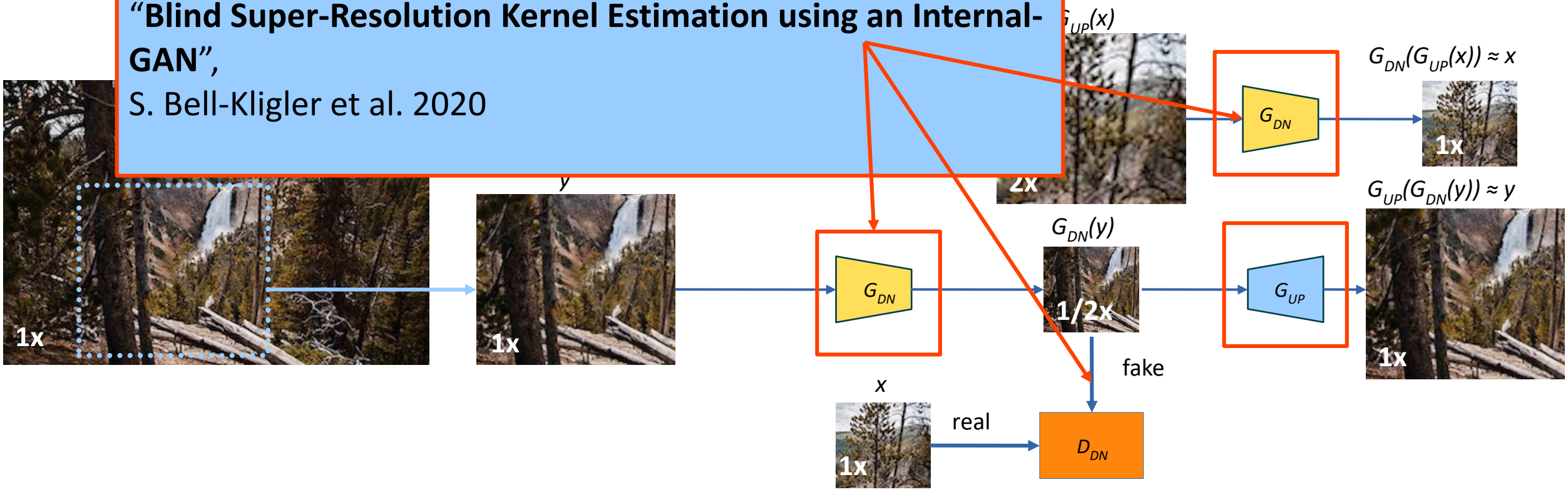
Generator Network Architecture





Network Architecture

“Blind Super-Resolution Kernel Estimation using an Internal-GAN”,
S. Bell-Kligler et al. 2020



Generator Network Architecture

- **Architecture Optimization for resource constrained device**
  - Width, Depth
  - Kernel Dimensions
  - Resolution Scaling (stride, pooling)
  - Weight Quantization
  - Network Pruning
- **Optimization for compute platform OpenGL ES**

Qualitative Results

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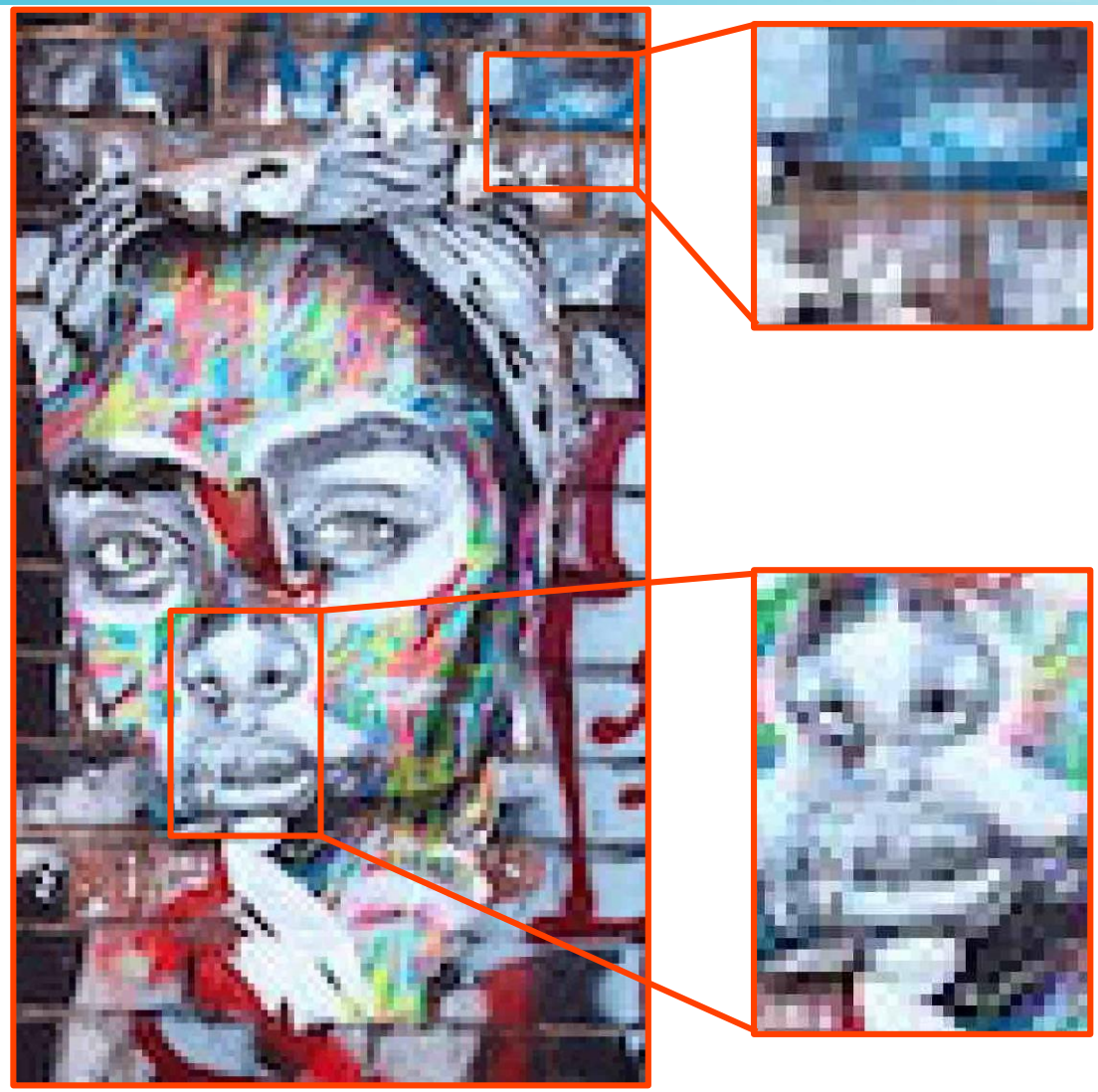
Qualitative Results

Nearest-Neighbor

interpolation



Qualitative Results

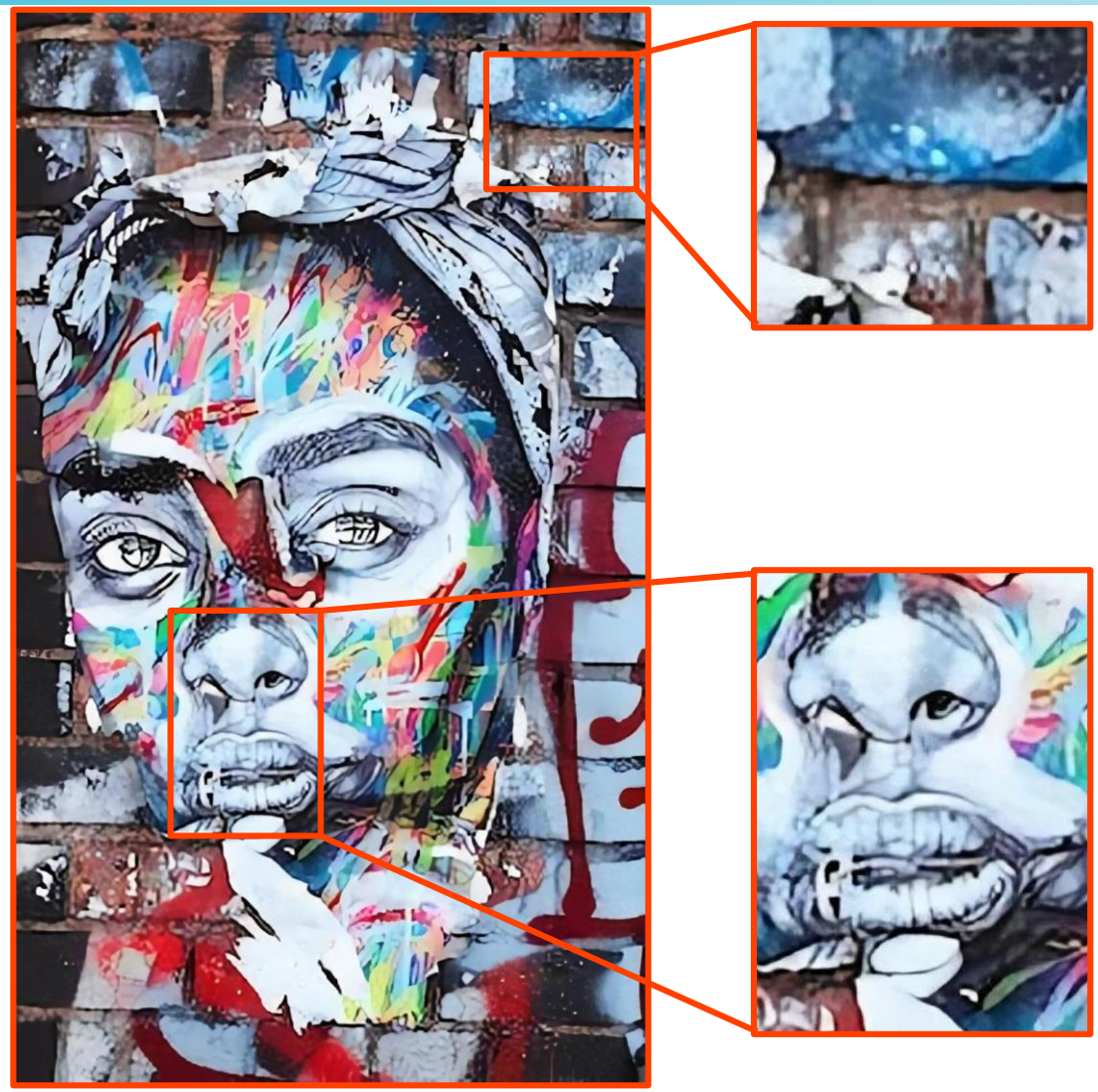
Bicubic

interpolation

Qualitative Results

VDSR

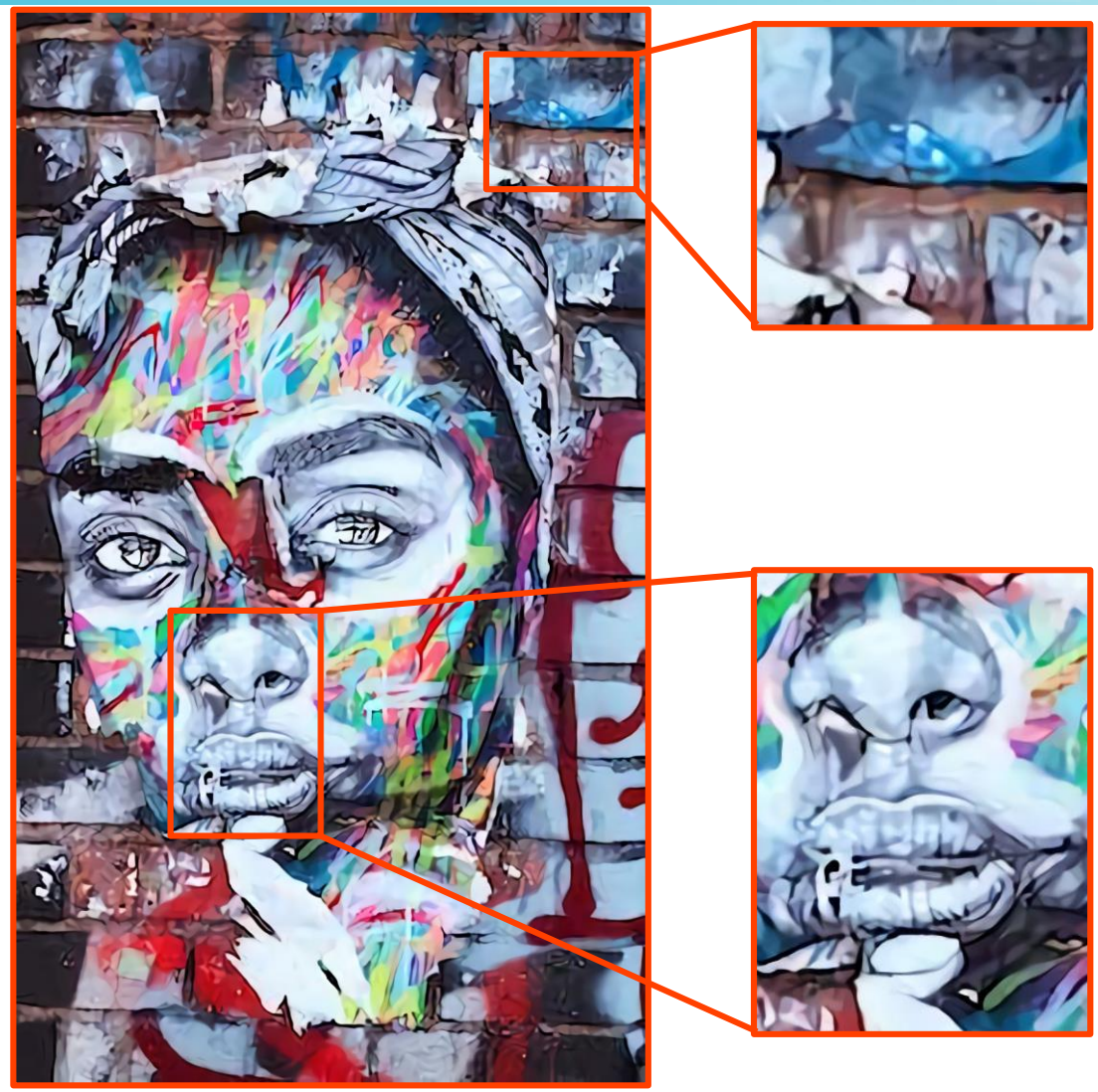
Super Resolution



Qualitative Results

EDSR

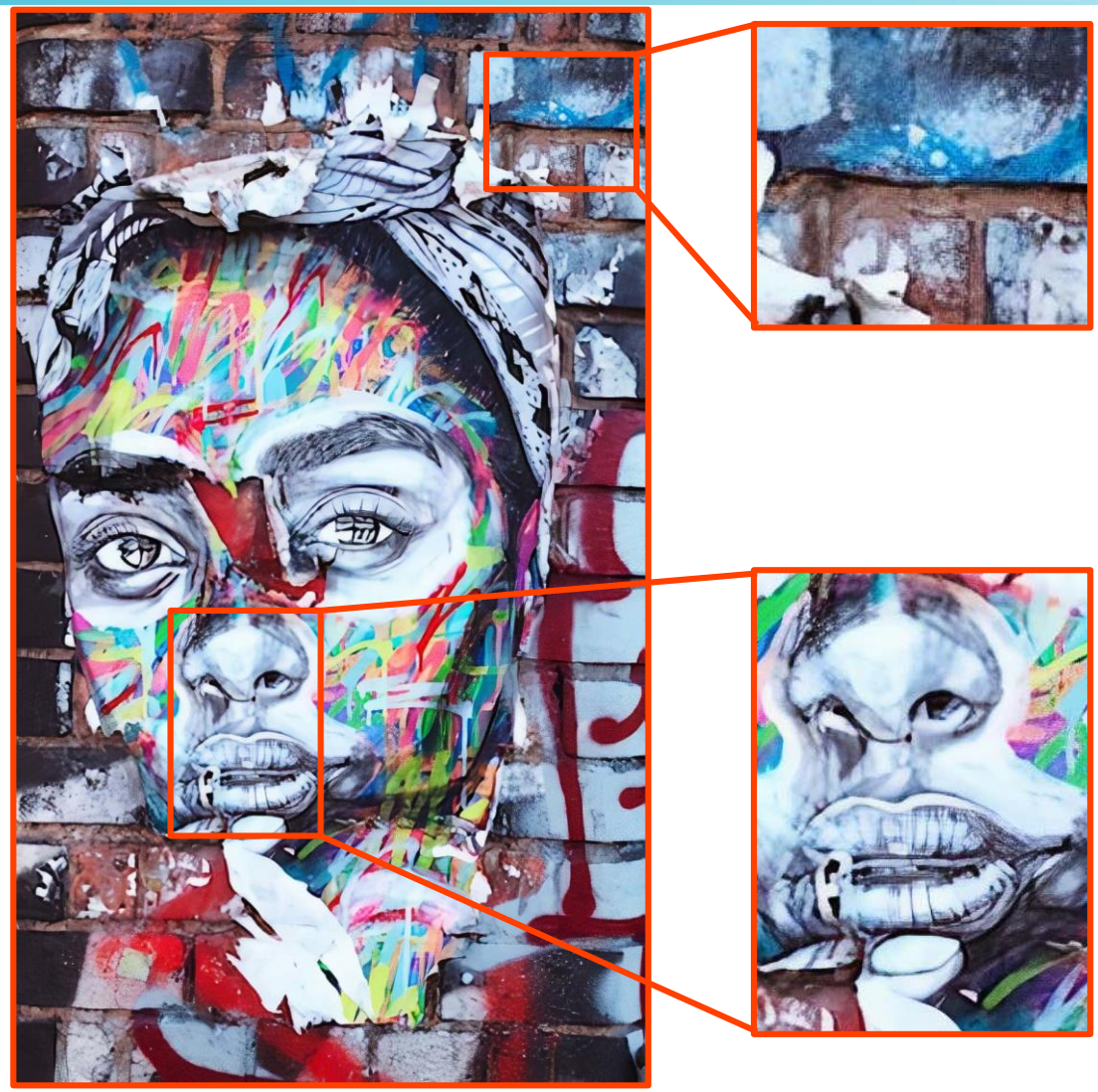
Super Resolution



Qualitative Results

RCAN-BAM

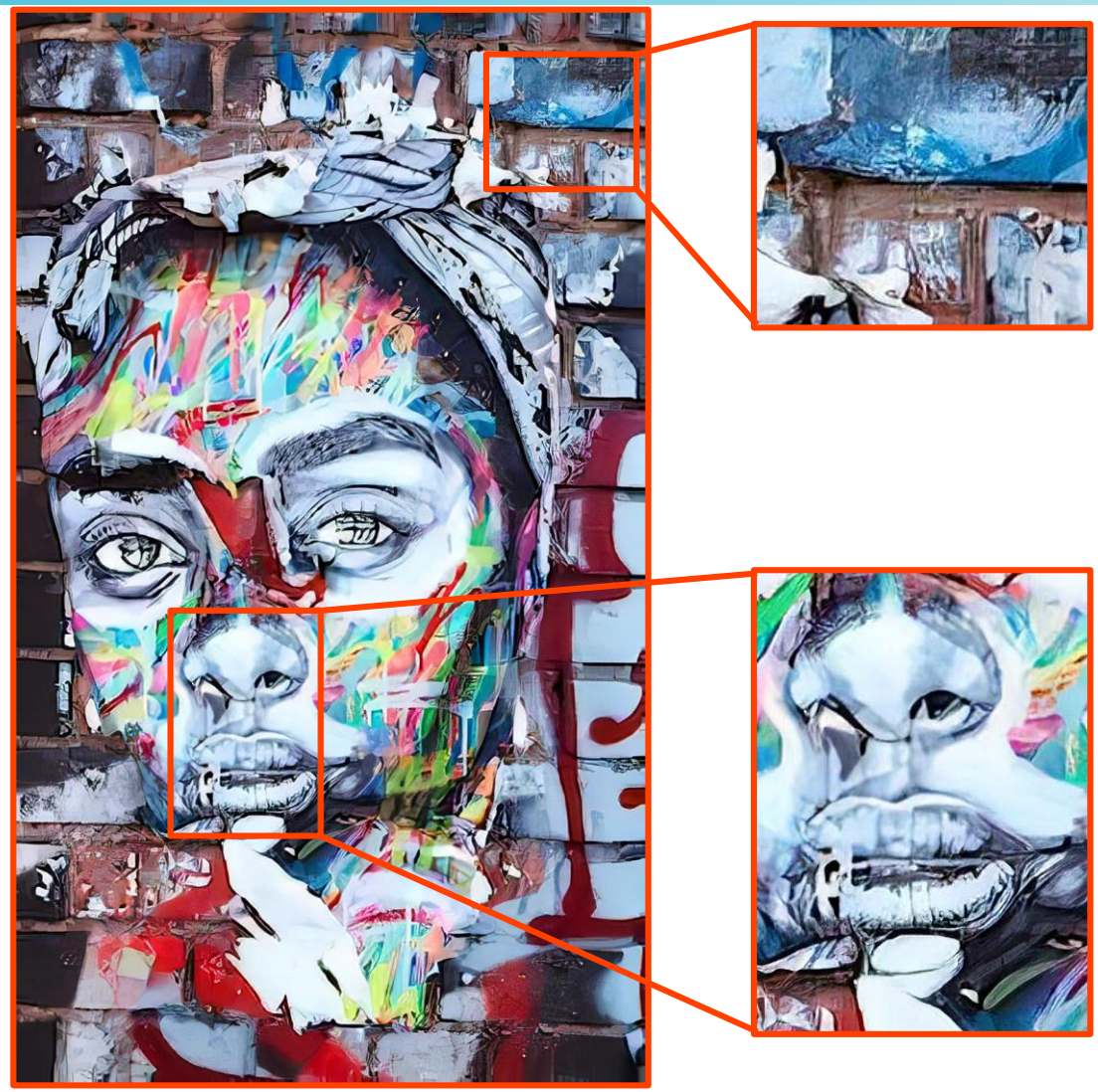
Super Resolution



Qualitative Results

Our

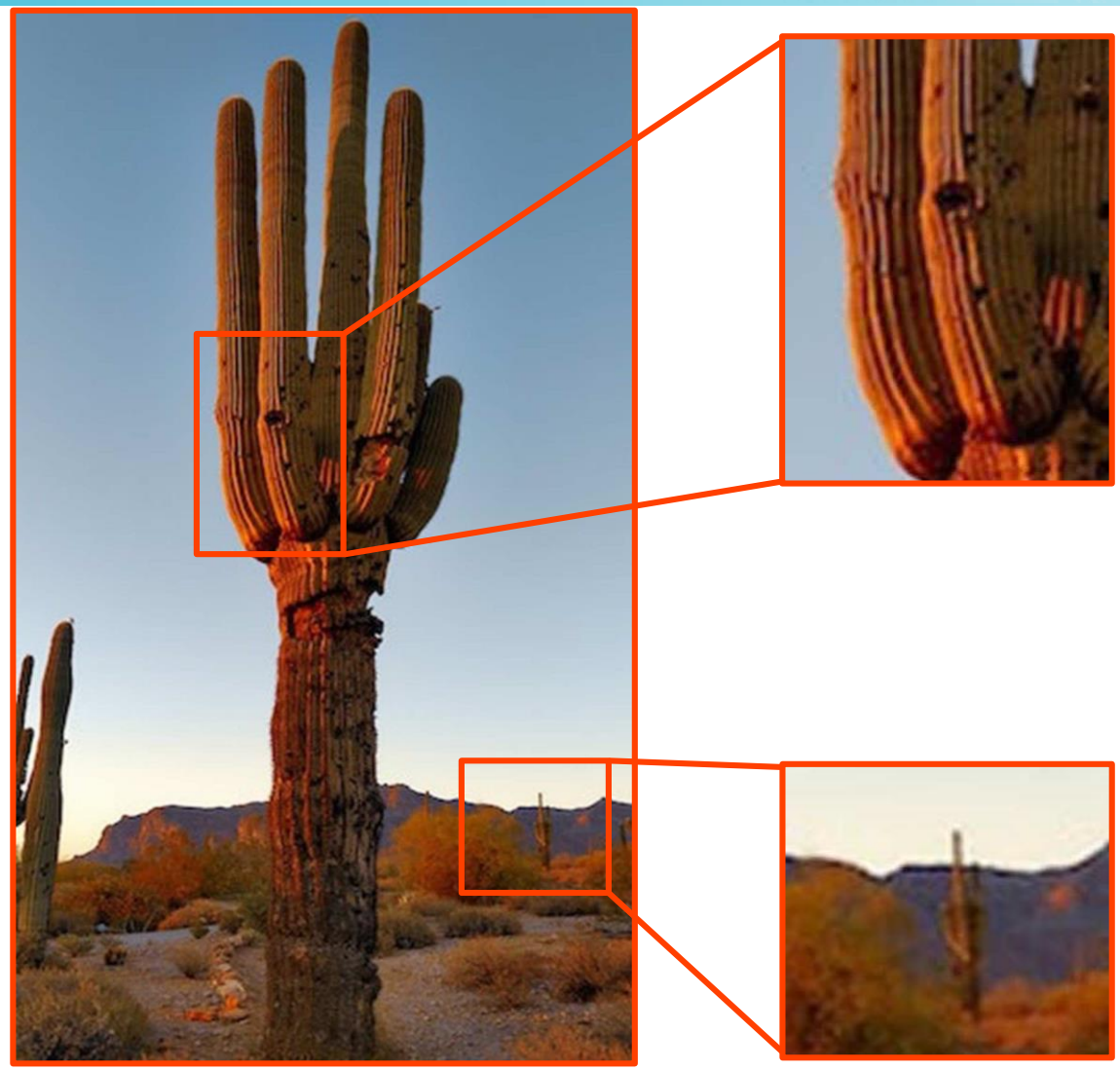
Super Resolution



Qualitative Results

Bicubic

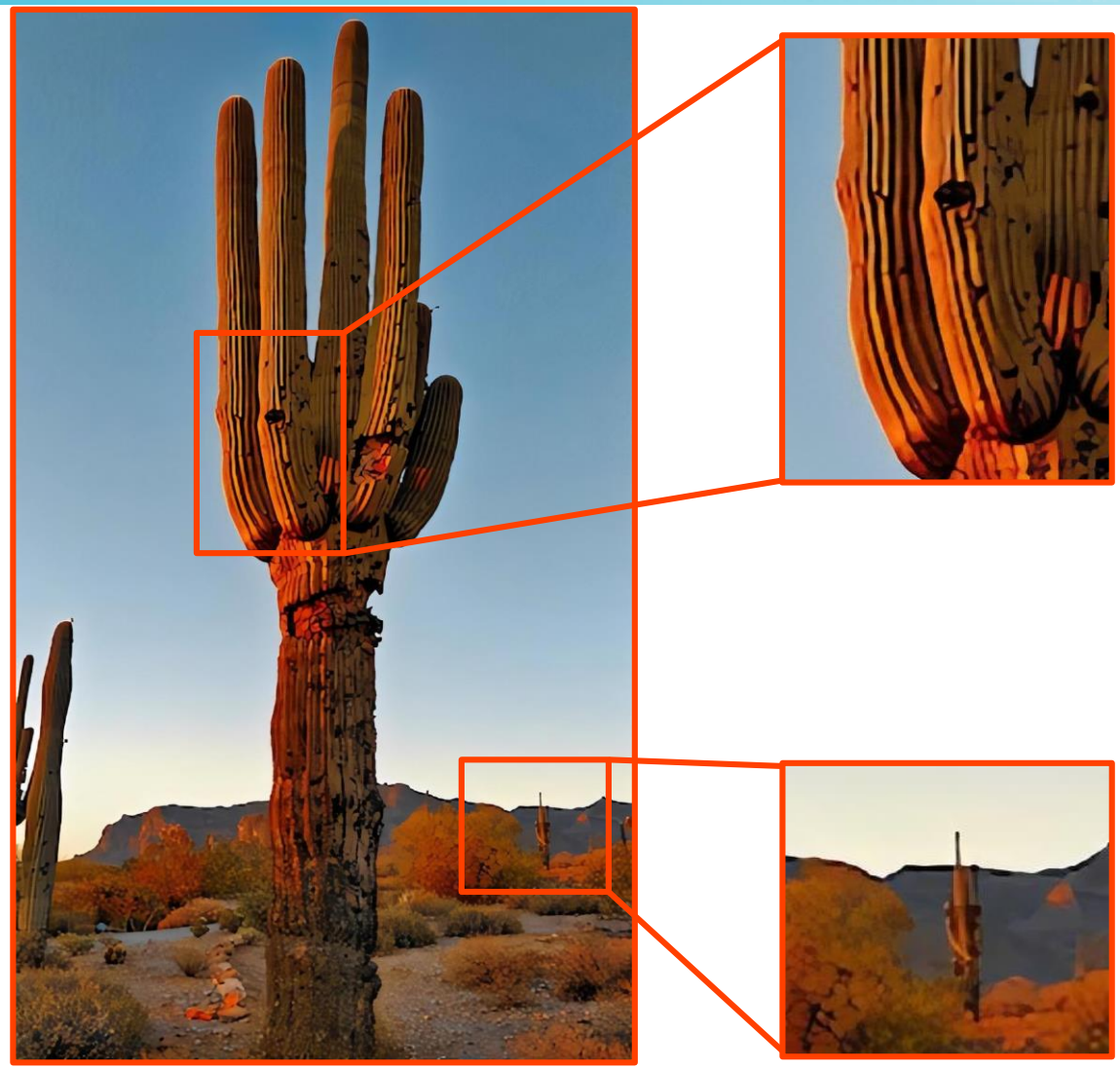
interpolation



Qualitative Results

VDSR

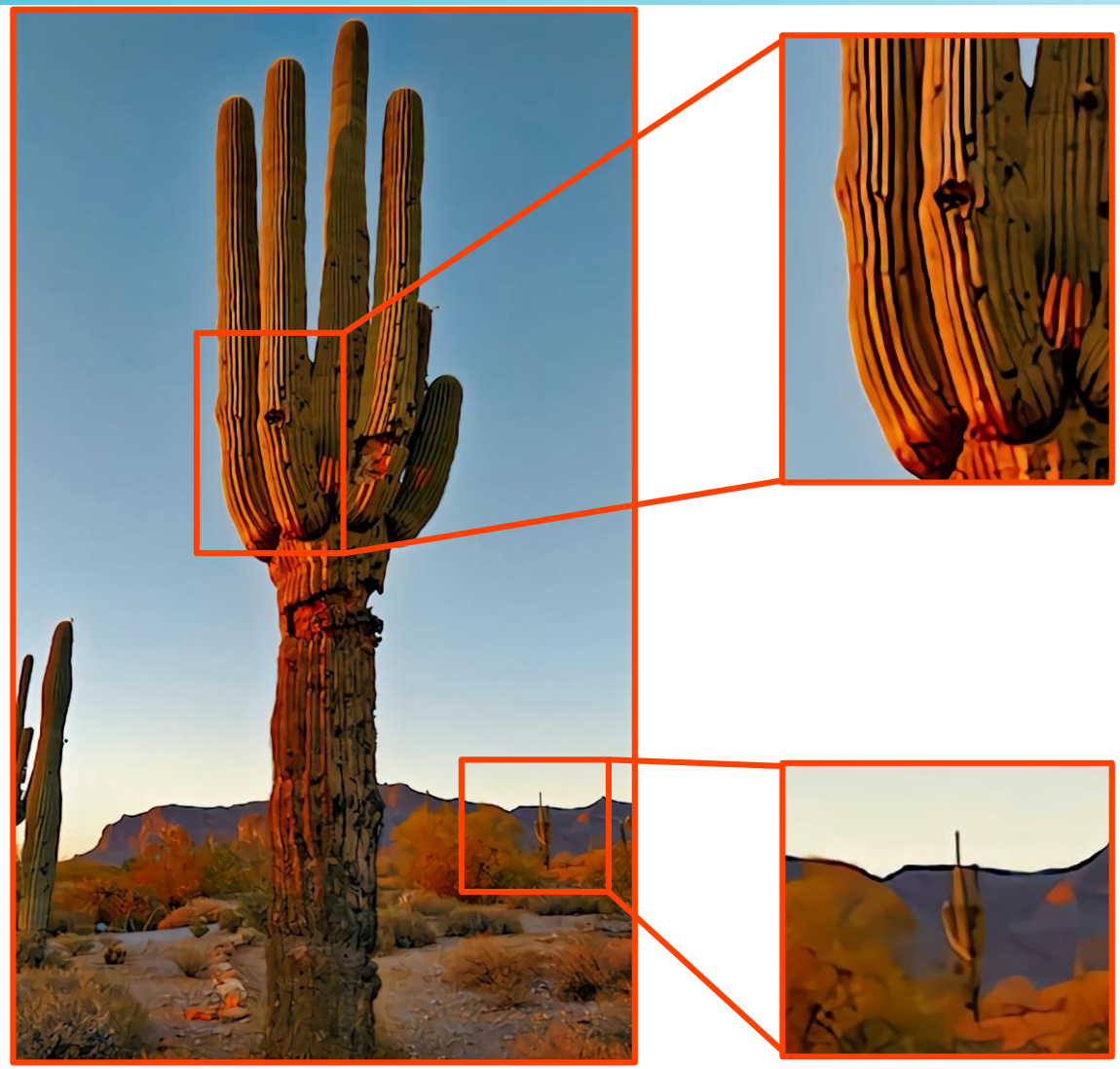
Super Resolution



Qualitative Results

EDSR

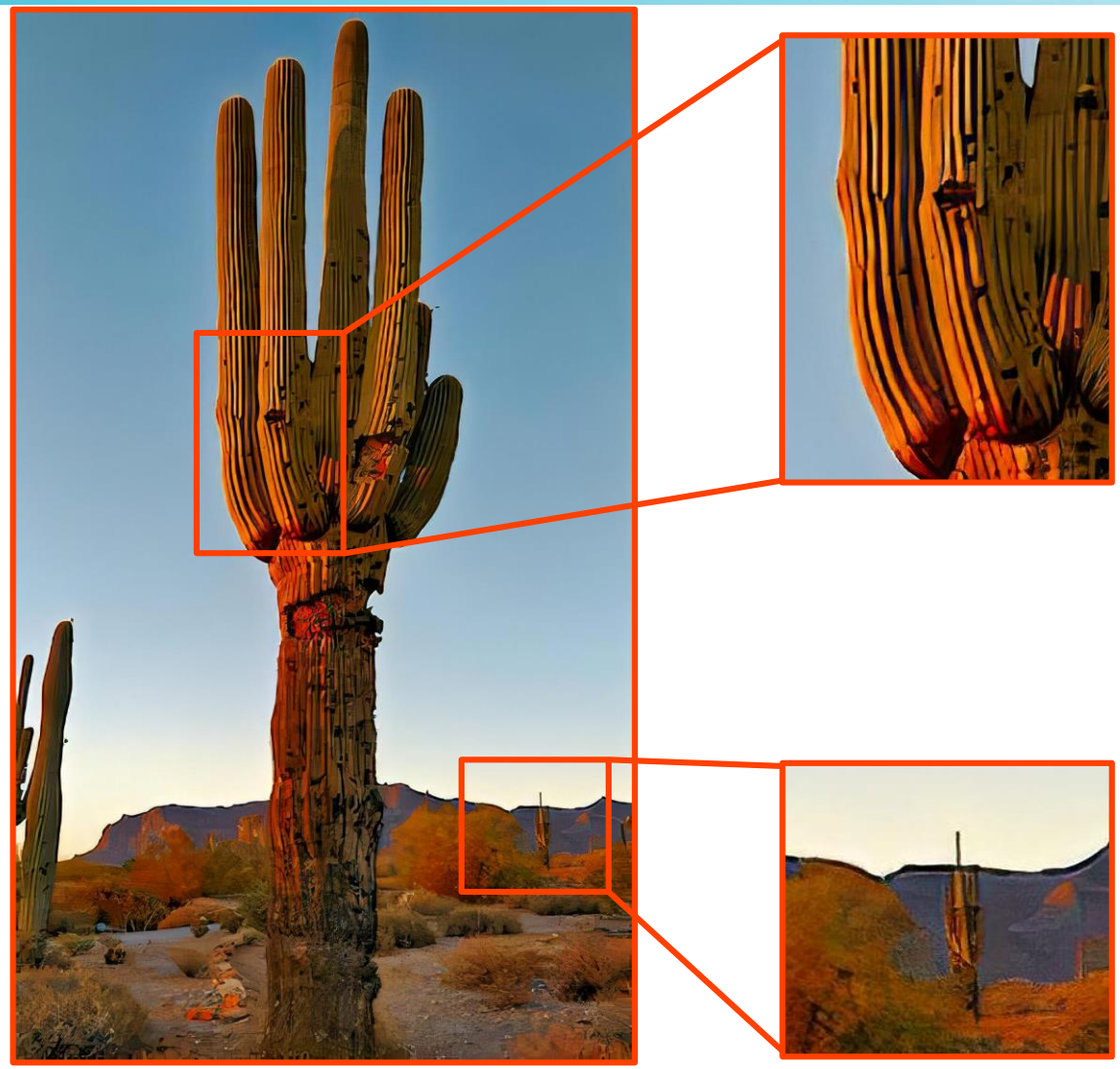
Super Resolution



Qualitative Results

RCAN-BAM

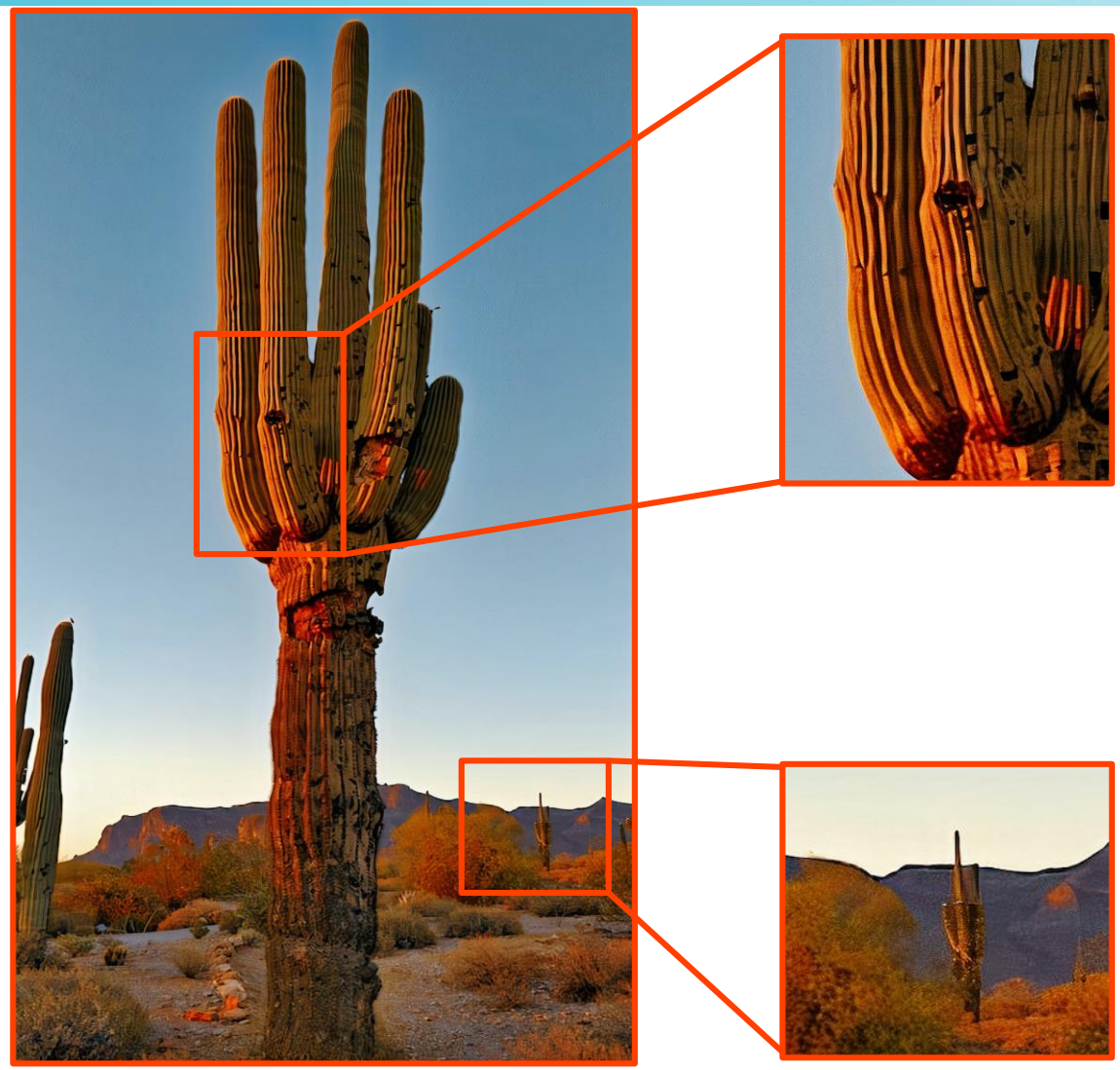
Super Resolution



Qualitative Results

Our

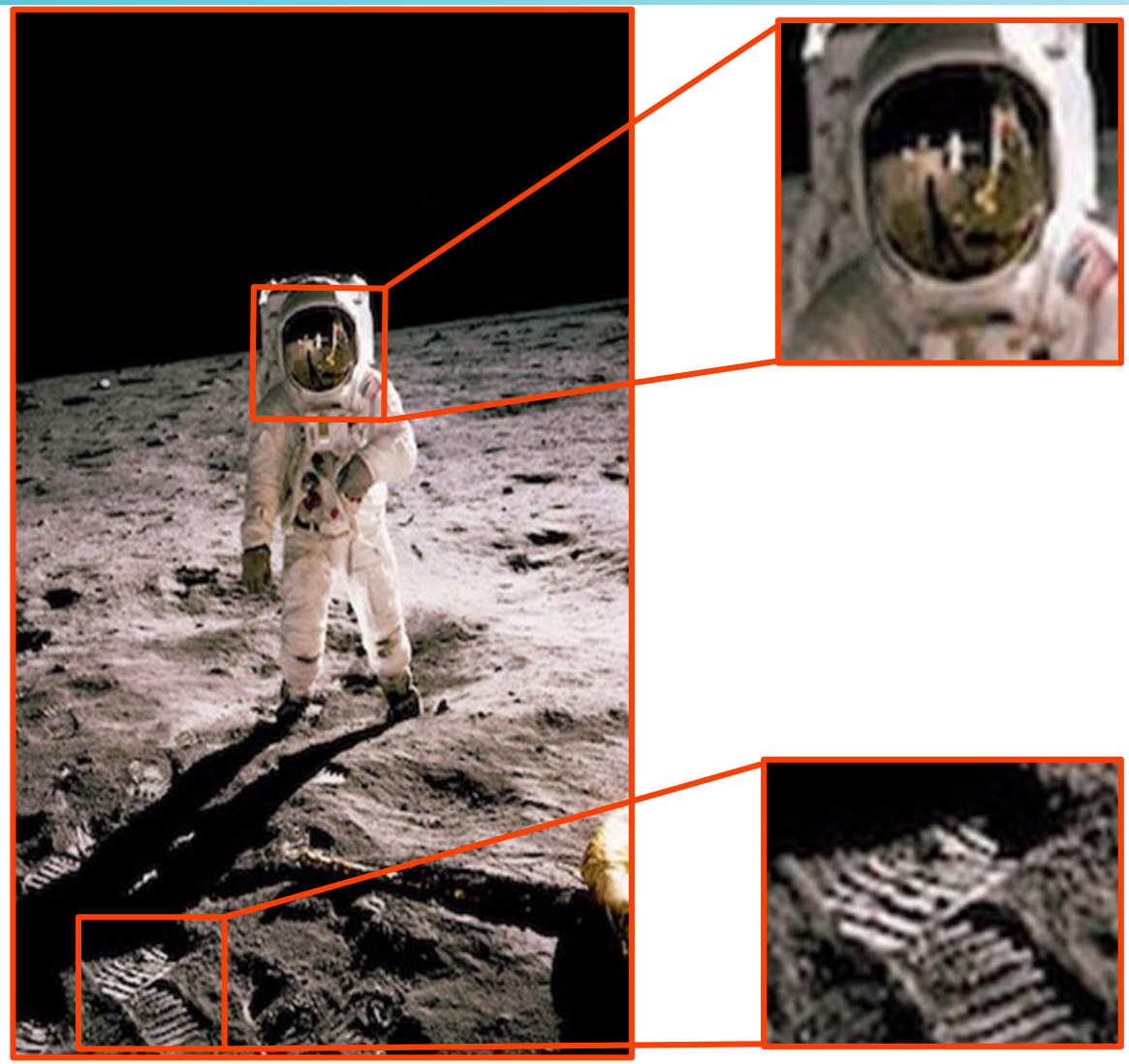
Super Resolution



Qualitative Results

Bicubic

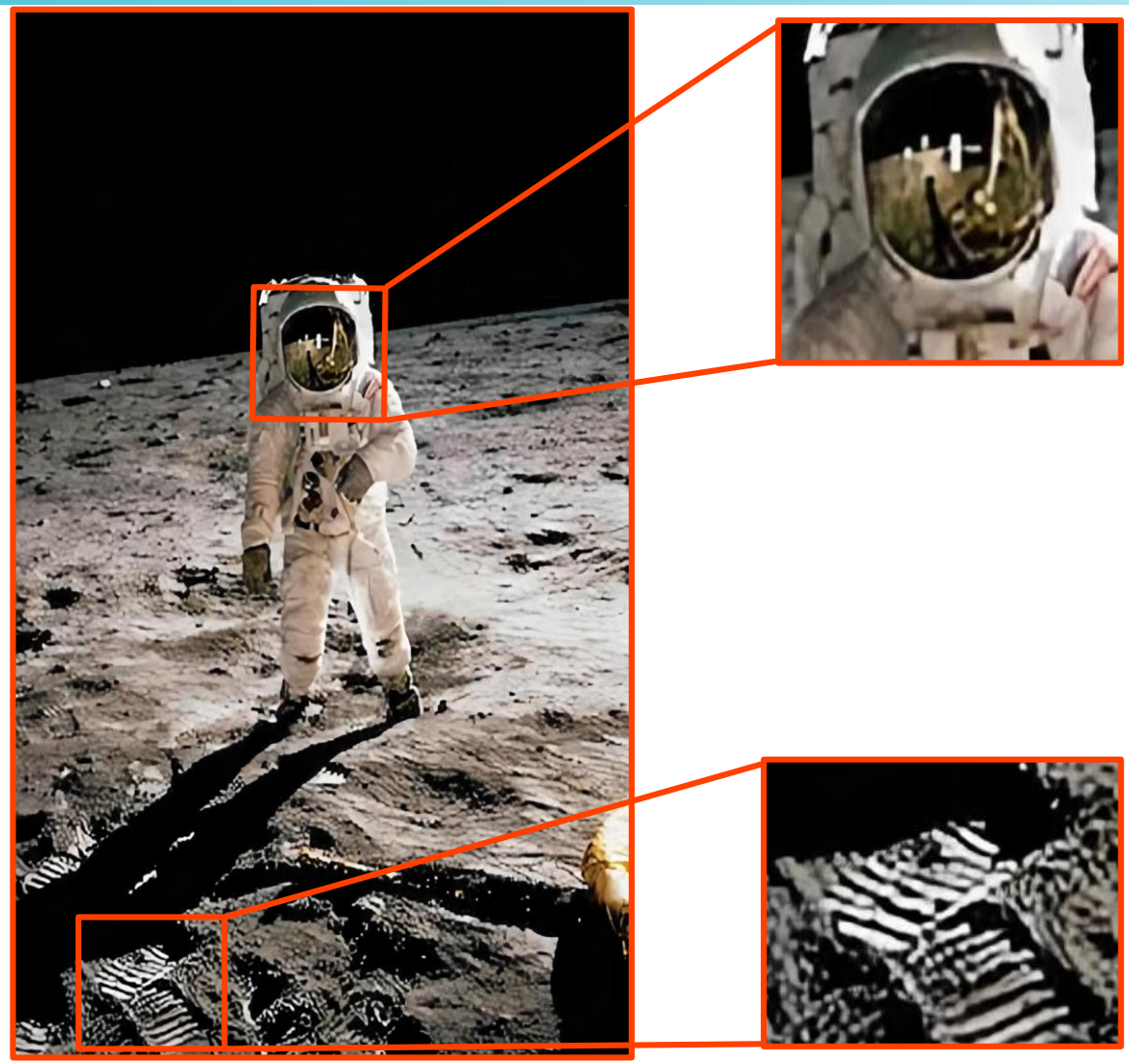
interpolation



Qualitative Results

VDSR

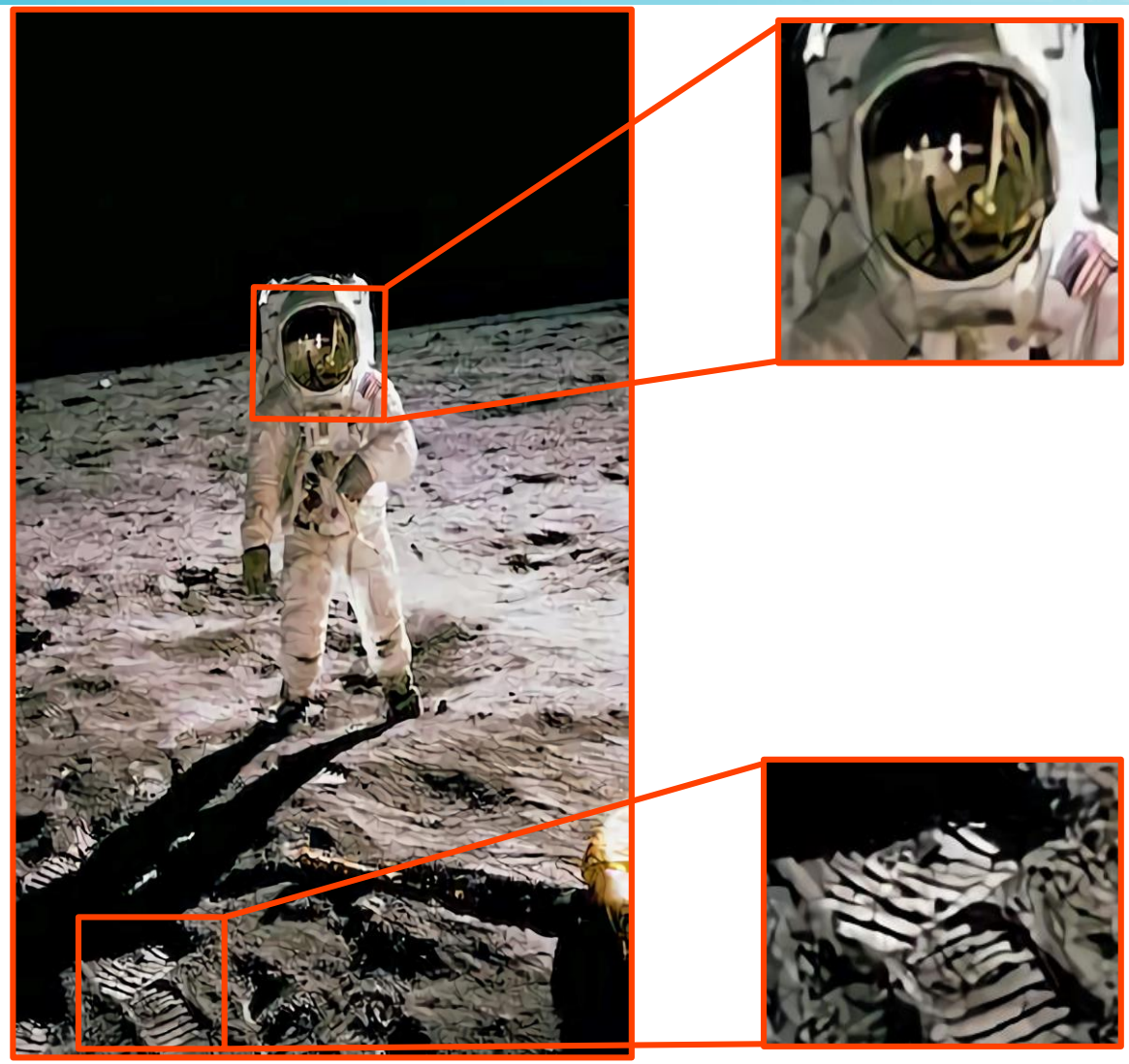
Super Resolution



Qualitative Results

EDSR

Super Resolution



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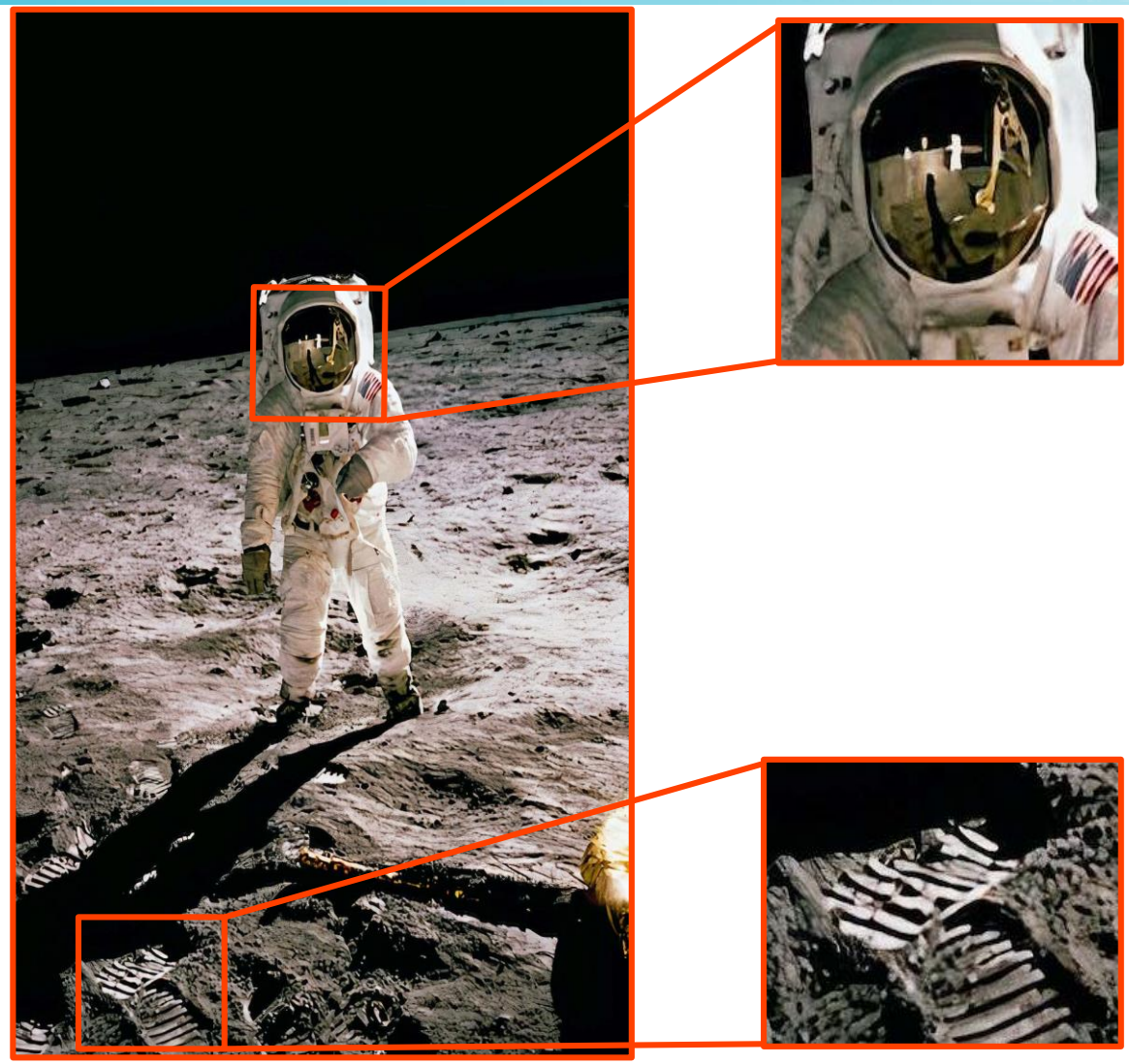
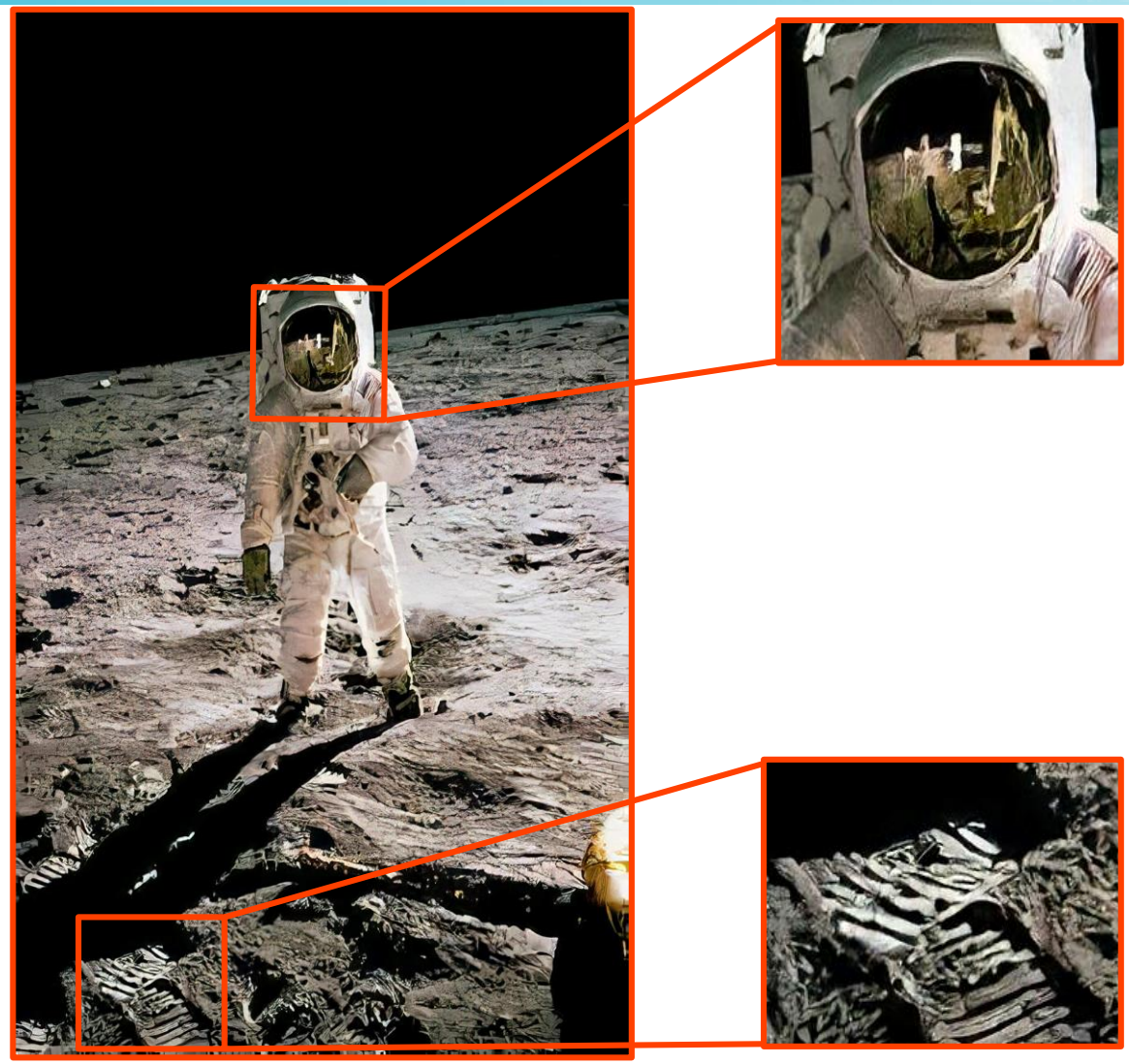
Super Resolution



Qualitative Results

Our

Super Resolution



Quantitative Results

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Results

- Quantitative results (PSNR / SSIM) for x2,x3,x4 on different datasets

Dataset	• Scale	Bicubic	VDSR	• EDSR	Ours
Urban-100	x2	26.88 / 0.8403	30.76 / 0.9140	32.93 / 0.9351	**33.45 / 0.9402**
	x3	24.46 / 0.7349	27.14 / 0.8279	28.80 / 0.8653	**30.04 / 0.9015**
	x4	23.14 / 0.6577	25.18 / 0.7524	26.64 / 0.8033	**28.02 / 0.843**
DIV2K	x2	31.01 / 0.9393	33.66 / 0.9695	35.03 / 0.9695	**35.78 / 0.9767**
	x3	28.22 / 0.8906	30.09 / 0.9208	31.26 / 0.9340	**32.07 / 0.9432**
	x4	26.66 / 0.8521	28.17 / 0.8841	29.25 / 0.9017	**30.14 / 0.9138**
B100	x2	29.56 / 0.8431	31.36 / 0.8879	32.32 / 0.9013	**32.89 / 0.9112**
	x4	25.96 / 0.6675	27.29 / 0.7251	27.71 / 0.7420	**28.22 / 0.8337**

Results

- VIM 3 - Amlogic A311D SBC with 5.0 TOPS NPU – evaluate a single 1080p image **~ 140 ms** (x2 upscaling)

- Compared to EDSR our optimized model is **2.5 times smaller**
- With an upscale factor of **2**, the **EDSR** model takes **0.4s** per frame whilst our model takes 0.14s per frame – 1080p output
- With an upscale factor of **4**, the EDSR model takes **0.56s** per frame whilst our model takes **0.2s** per frame – 1080p output

Summary

- Estimate the SR-kernel from the low-resolution Image
  - Super-Resolution in the wild on resource constrained devices
- Optimize Super-Resolution Network through given kernel
  - Deep Networks are redundant and can be reduced
- Maximal computational efficiency through utilizing specialized hardware

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Thank You !