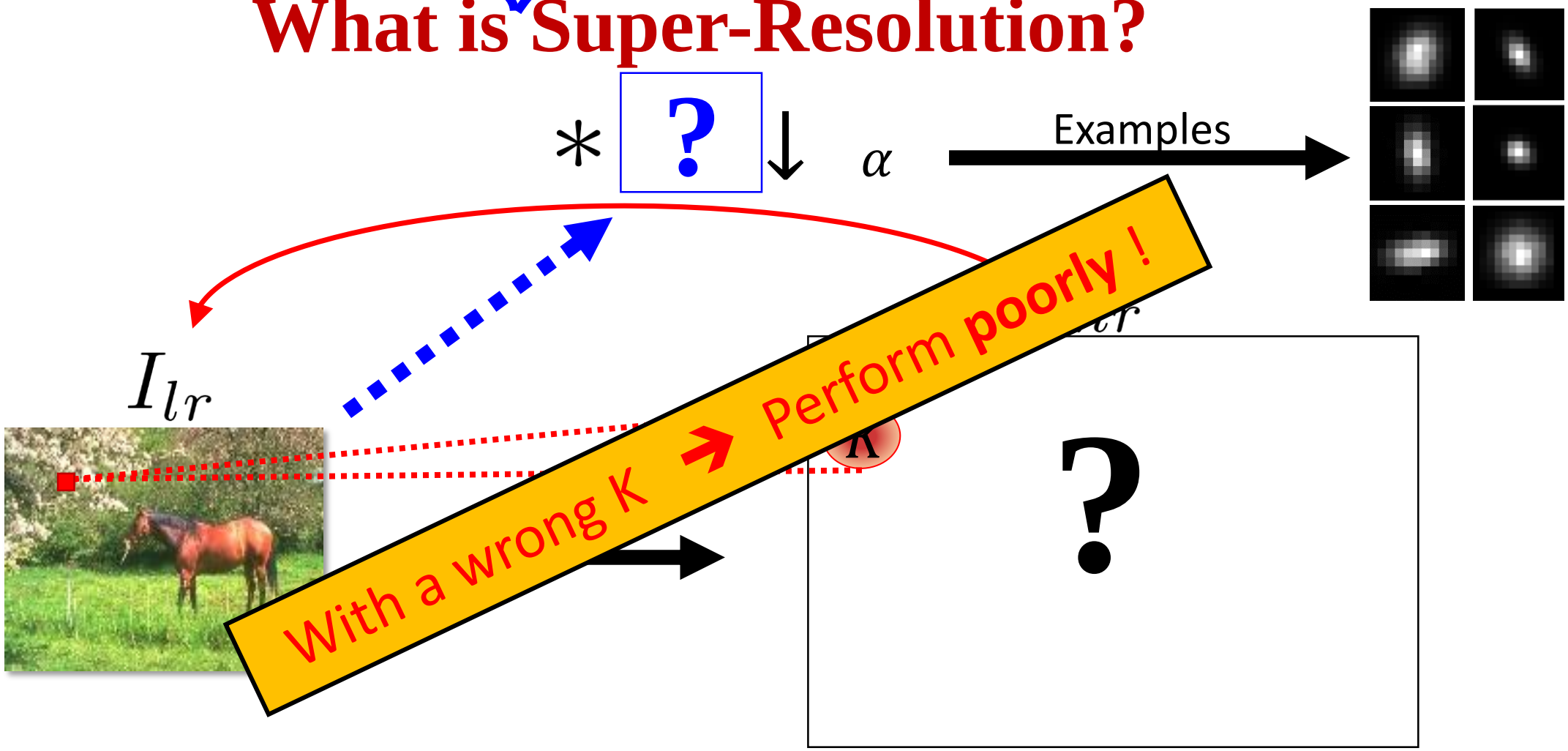
“KernelGAN”

Blind SR Kernel Estimation using an Internal-GAN

Sefi Bell-Kligler *Assaf Shocher* *Michal Irani*

Weizmann Institute of Science

Blind
What is Super-Resolution?



Current leading SR methods ➔ Deep-Learning based

[***EDSR+*** *: Lim et al 2017,* ***RCAN+*** *: Zhang et al 2018*]

In this work

?

I_{lr}

- Estimate the **image-specific** SR-kernel
- Fully **unsupervised** - **Zero examples**

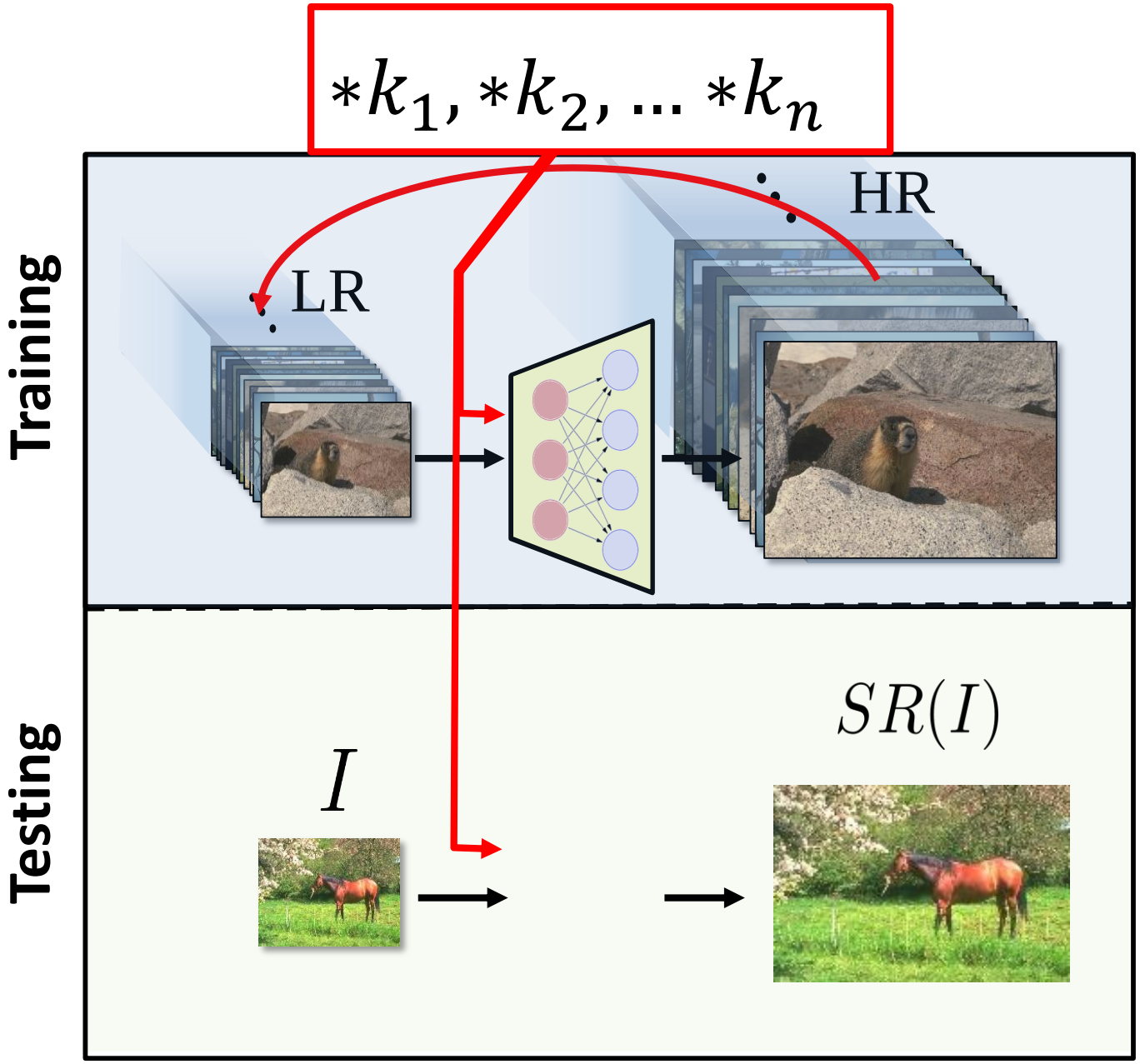
  ➔ Trains on the test image only!
- First practical use of **Deep Linear** Networks

SotA results in Blind-SR

⬇

SR in the wild

The problem with existing SR methods



Three types of SR methods:

1. Implicitly assume **K**

   [RCAN, Zhang et al.; EDSR, Lim et al.]

2. Agnostic to K

   [PDN, Xianto et al; WDSR, Yu et al.]

3. Receive K as input

   [ZSSR, Shocher et al; SRMD, Zhang et al.]


EDSR, Lim et al.

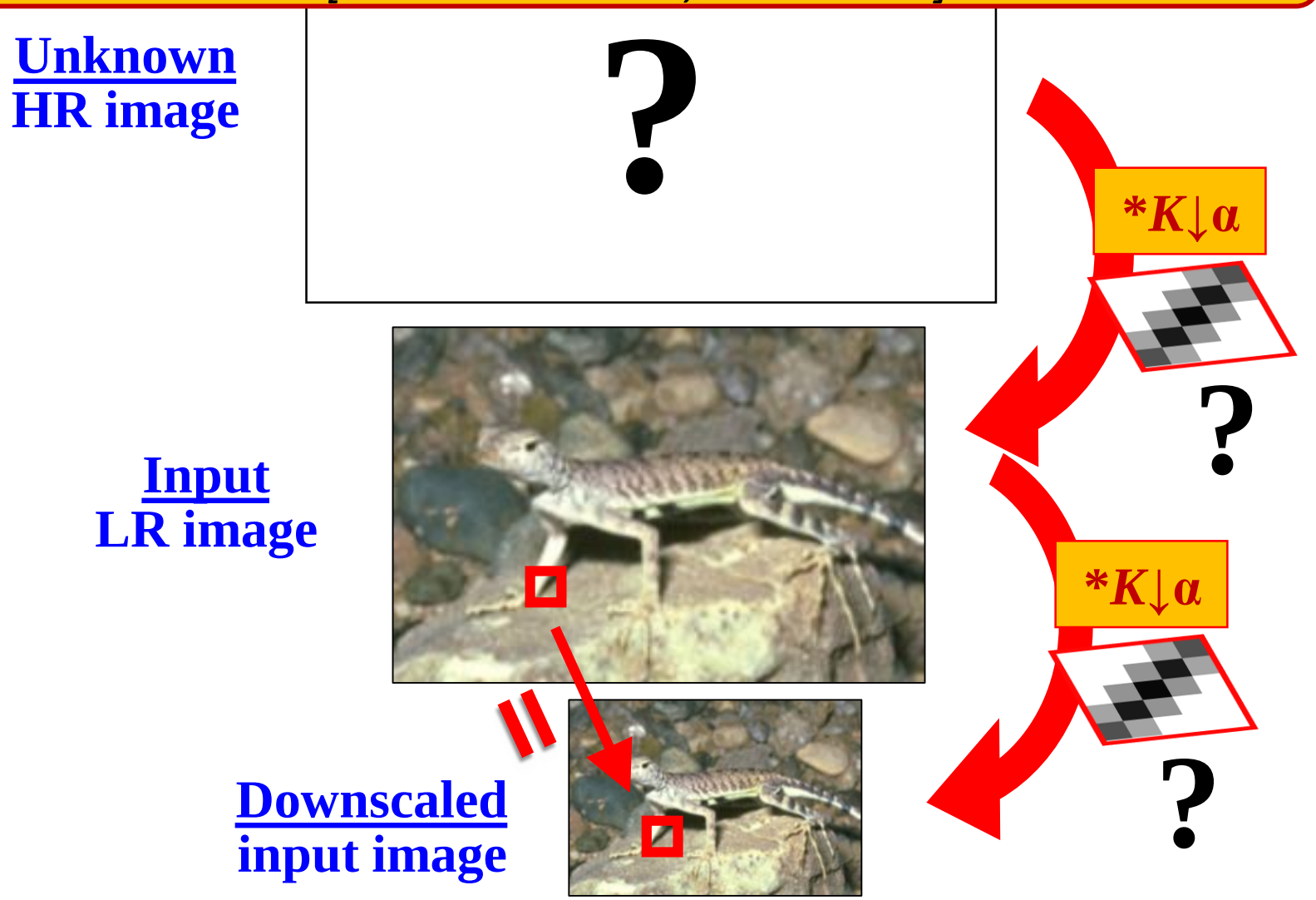
SR with Image-Specific Kernel [ZSSR]

SR-Kernel K ➔ more important than SR-method

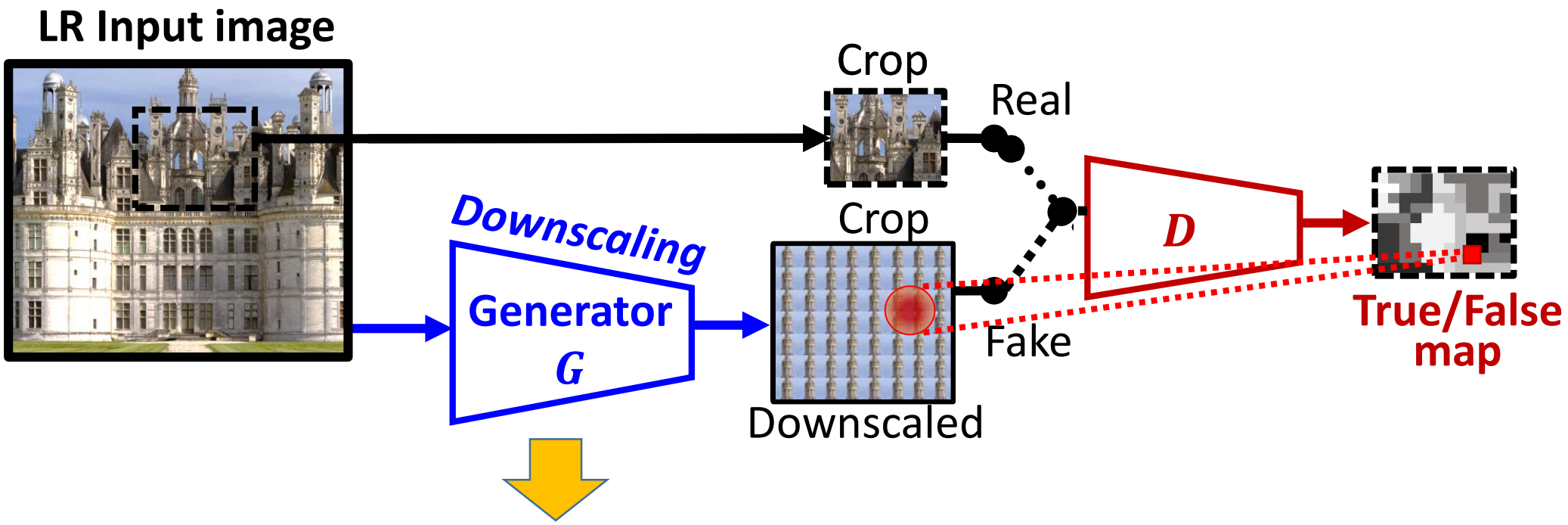
The Correct SR Kernel

➔ **Maximizes patch similarity across scales of LR**

[Michaeli & Irani, ICCV'2013]



"KernelGAN" – *Kernel Estimation via Internal-GAN*



The correct downscaling:

$$* \; K \downarrow_{\alpha}$$

The Generator G = $* \boldsymbol{k} \downarrow_{\alpha}$

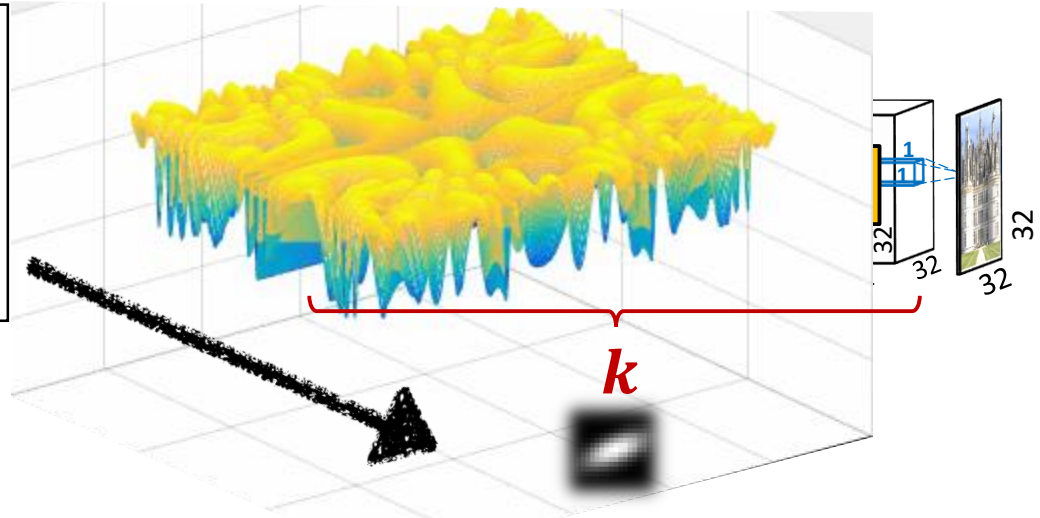
Usually in DL:

Single global minimum

ns

$$\mathbf{G}(\boldsymbol{I}_{LR}) = (\boldsymbol{I}_{LR} * \boldsymbol{k}) \downarrow_{\alpha}$$

The correct SR_{Kernel}

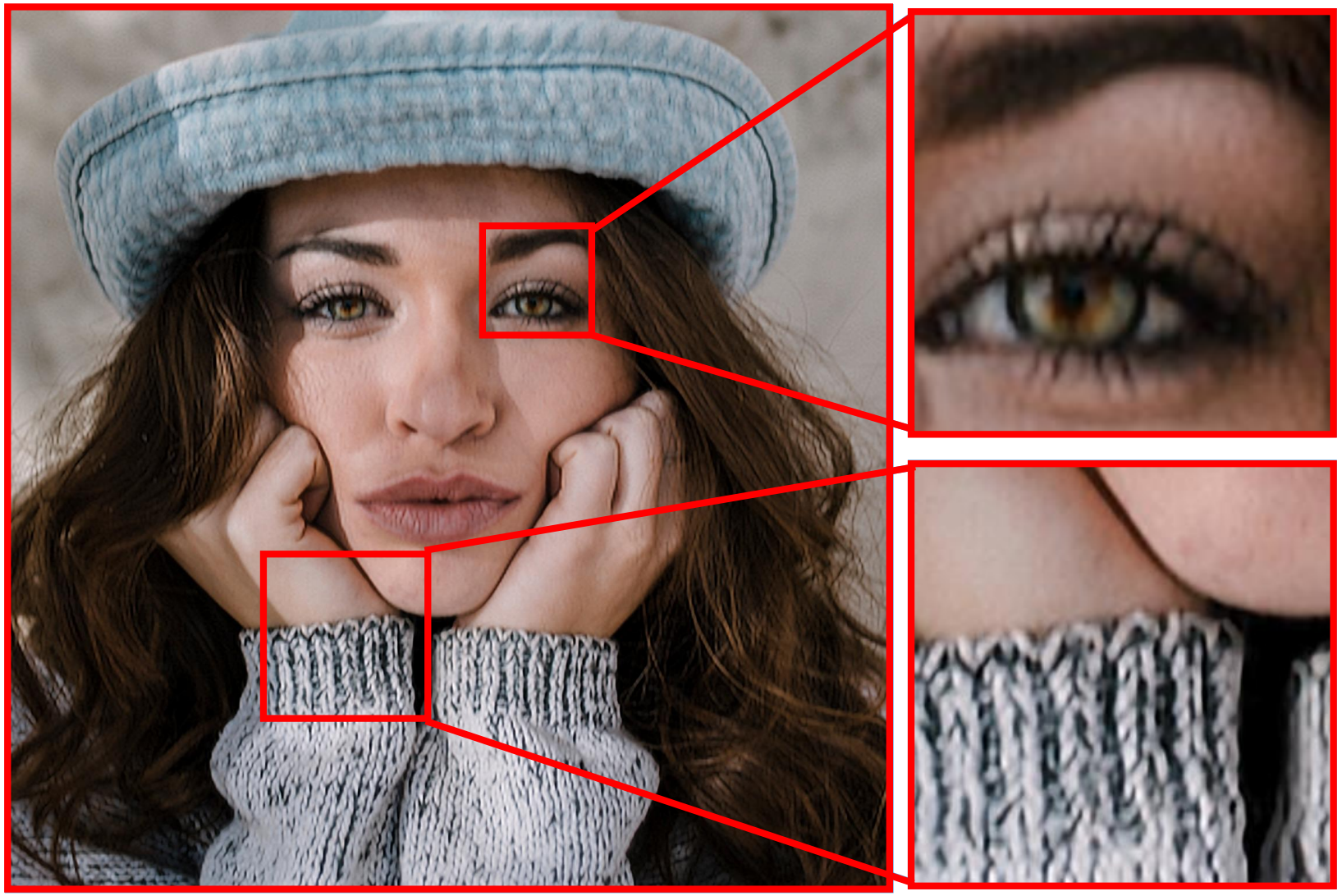


=

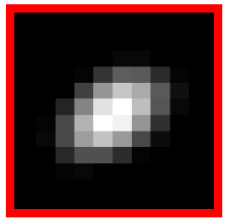
Infinitely many good minima!!!

First practical use of Deep Linear Networks

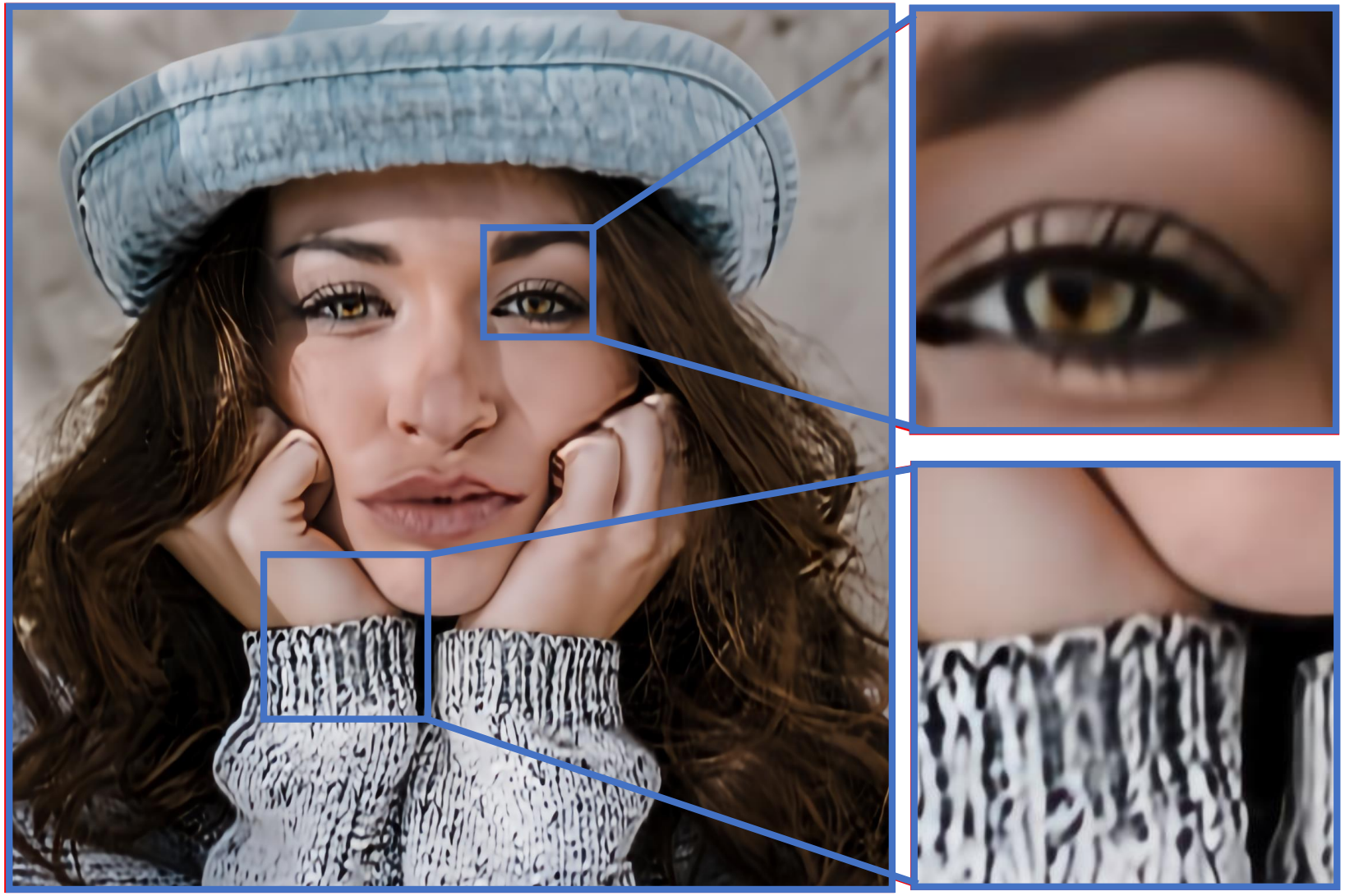
KernelGAN (Ours) + ZSSR



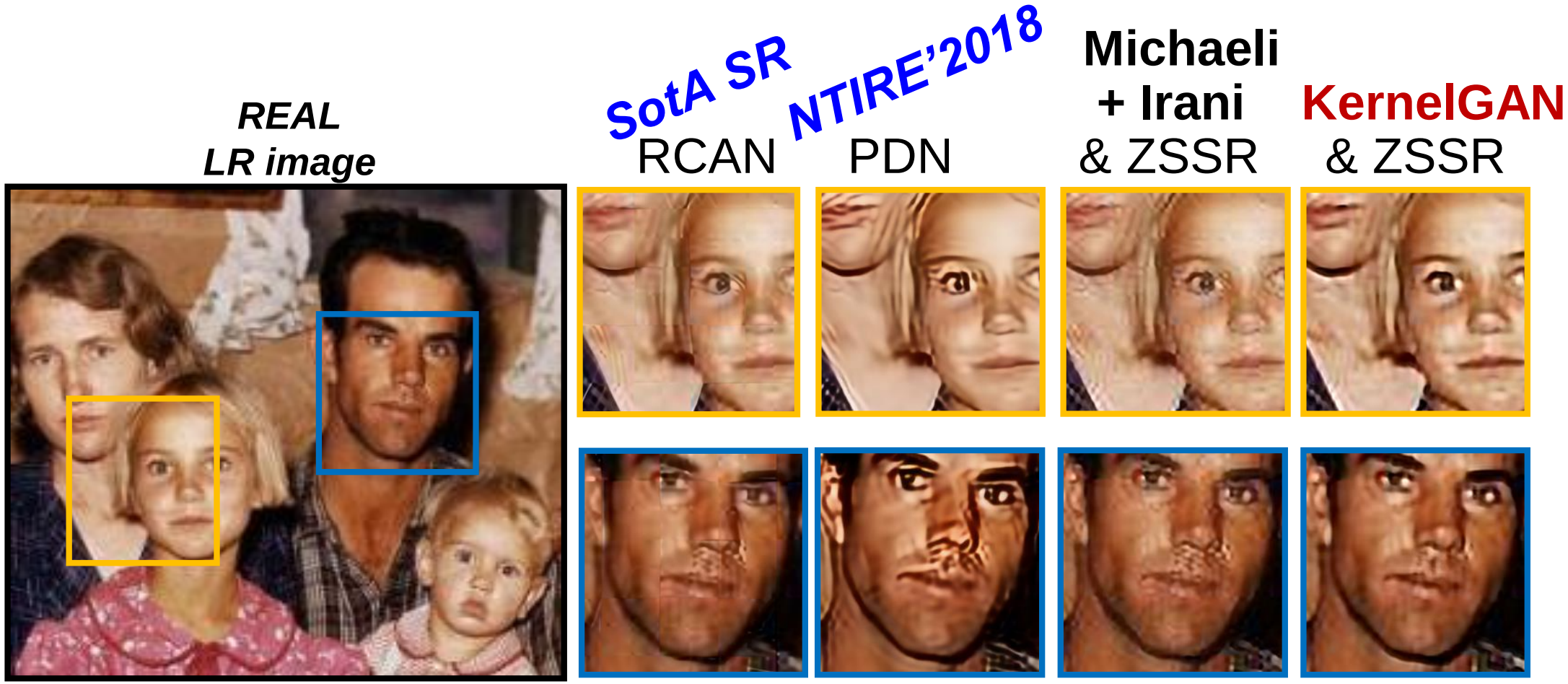
Estimated SR-kernel



PDN – “Blind-SR” Challenge Winner 2018



Visual Comparison to SotA SR



Quantitative Evaluation

Method	× 2	× 4
Bicubic Interpolation	28.73/0.804	25.33/0.679
Bicubic K + ZSSR	29.10/0.822	25.61/0.69[illegible]
EDSRplus	29.17/0.822	[illegible]
RCANplus	29.20/0.[illegible]	[illegible]
PDN #1 NTIRE (T4)	[illegible]	[illegible]/0.719
WDSR #1 NTIRE (T[illegible]	[illegible]	21.55/0.684
WDSR #1 N[illegible]	-	21.54/0.702
W[illegible]	-	25.64/0.714
[illegible] + SRMD	25.51/0.808	23.34/0.653
[illegible]n&Irani + ZSSR	29.37/0.837	26.08/0.714
KernelGAN(ours) + SRMD	29.56/0.856	25.71/0.726
KernelGAN(ours) + ZSSR	30.36/0.867	26.81/0.732

We outperform all methods by 0.47-1dB

Conclusion

"KernelGAN" -- Estimate the SR-kernel k from the LR image

- Fully **unsupervised** -- **Zero examples:**
  - Trains on the LR input image only
  - **Image-specific** "Internal-GAN"

- First practical use of **Deep Linear** Networks

State of the Art Blind-SR ➔ "SR in the Wild"

wisdom.weizmann.ac.il/~vision/kernelgan