Infrared Image Super-Resolution

via Heterogeneous Convolutional WGAN

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Self-Introduction

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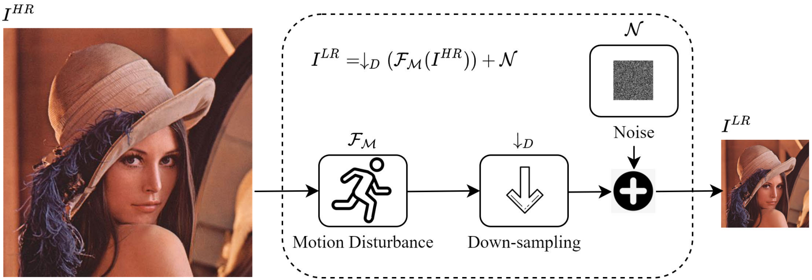
University

Guilin University of Electronic Technology, China

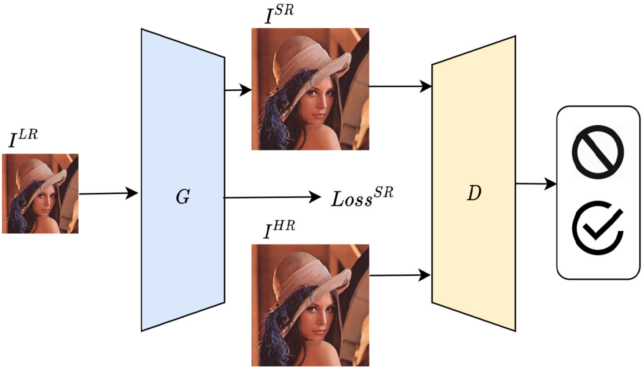
Research Topics

Computer Vision
Image Processing
Generative Adversarial Networks

Single image super-resolution (SISR).



Generative adversarial networks(GANs)



$$\min_G \max_D V(D,G) = E_{x\sim p_{\text{data}}\ (x)}[\log D(x)] + E_{z\sim p_z(z)}[\log(1-D(G(z)))]$$

Generator Network

$G : P_G(x;\theta)$ **Step.1** Sample $\{x^1, x^2, \ldots, x^m\}$ from $P_{\text{data}}(x)$

Step.2 $L = \prod_{i=1}^{m} P_G(x^i;\theta)$

$x_{\sim p_{data}} \in I^{LR}$

Step.3

$$\theta^* = \arg\max_\theta \prod_{i=1}^{m} P_G(x^i;\theta) = \arg\max_\theta \log \prod_{i=1}^{m} P_G(x^i;\theta)$$

$$= \arg\max_\theta \sum_{i=1}^{m} \log P_G(x^i;\theta)$$

$$\approx \arg\max_\theta E_{x\sim P_{\text{data}}}[\log P_G(x;\theta)]$$

$$= \arg\max_\theta \int_x P_{\text{data}}(x)\log P_G(x;\theta)dx - \int_x P_{\text{data}}(x)\log P_{\text{data}}(x)dx$$

$$\boxed{= \arg\min_\theta KL(P_{\text{data}} \| P_G)}$$

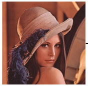
$z_{\sim p_G} \in I^{SR}$

$Loss^{SR}$

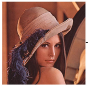
Discriminator Network

$$V(G,D)=E_{x\sim P_{\text{data}}}[\log D(x)]+E_{x\sim P_G}[\log(1-D(x))]$$

$x_{\sim p_G}\in I^{SR}$



$x_{\sim p_{data}}\in I^{HR}$



$$V=E_{x\sim P_{\text{dux}}}[\log D(x)]+E_{x\sim P_G}[\log(1-D(x))]$$

$$=\int_x P_{\text{data}}(x)\log D(x)dx+\int_x P_G(x)\log(1-D(x))dx$$

$$=\int_x\left[P_{\text{data}}(x)\log D(x)+P_G(x)\log(1-D(x))\right]dx$$

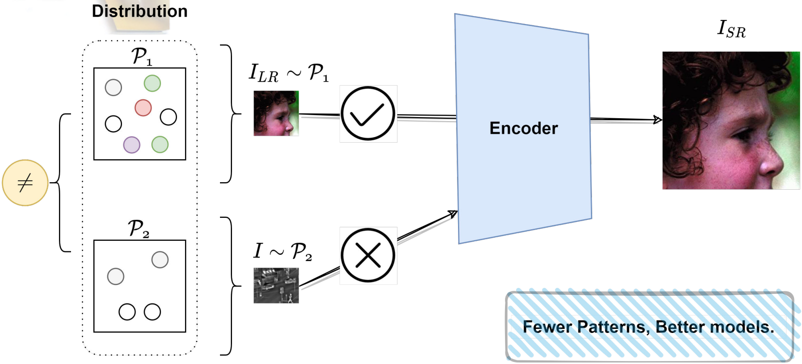
$$\because D^*(x)=\frac{P_{\text{data}}(x)}{P_{\text{data}}(x)+P_G(x)}$$

$$=-2\log 2+\mathrm{KL}\left(P_{\text{data}}\|\frac{\mathrm{P}_{\text{data}}+\mathrm{P}_{\mathrm{G}}}{2}\right)+\mathrm{KL}\left(\mathrm{P}_{\mathrm{G}}\|\frac{\mathrm{P}_{\text{data}}+\mathrm{P}_{\mathrm{G}}}{2}\right)$$

$$\boxed{=-2\log 2+2\,\mathrm{JS}(P_{\text{data}}\|P_G)}$$

Ref: $JS(p\|q)=\frac{1}{2}KL\left(p\|\frac{p+q}{2}\right)+\frac{1}{2}KL\left(q\|\frac{p+q}{2}\right)$

Method is needed.



Datasets

Training

1,000 infrared images.

Test

TWO test datasets available for evaluation.

Link

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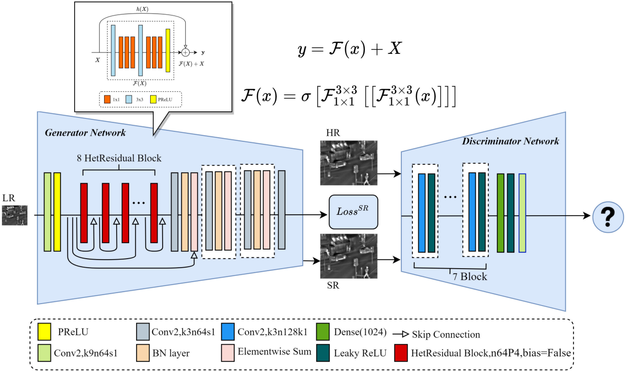
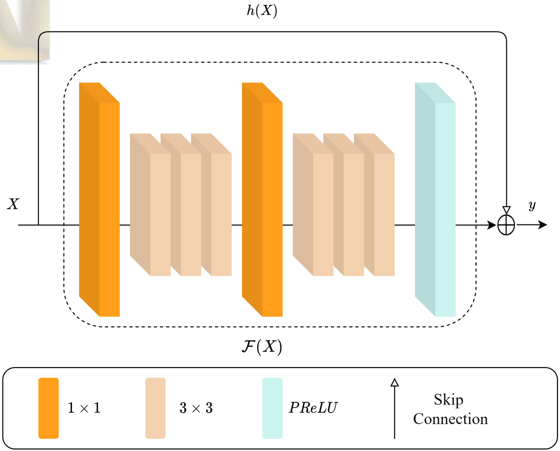
HetSRWGAN

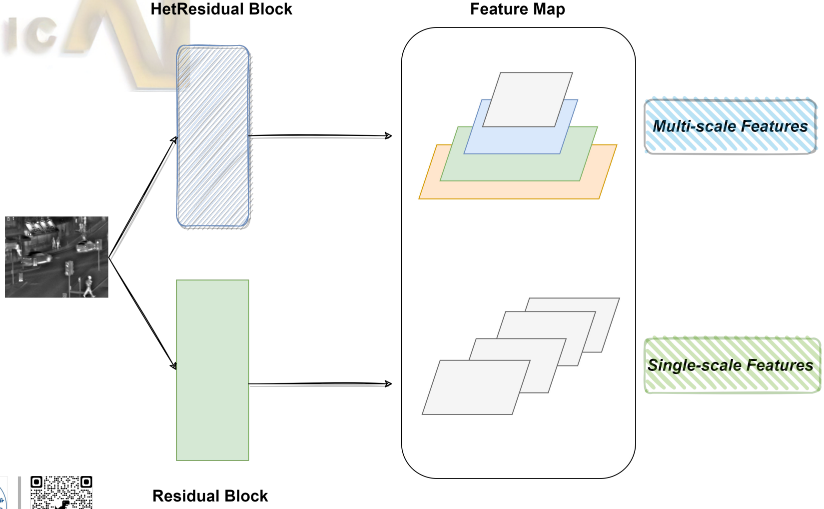
- The HetSRWGAN is a lightweight GAN architecture that applies a plug-and-play Heterogeneous Kernel-Based Residual Block.



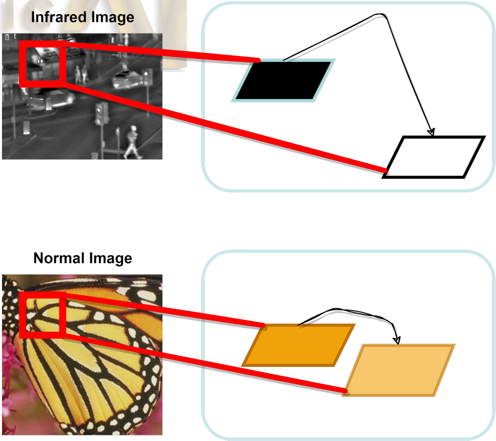
Heterogeneous Kernel-Based Residual Block



Feature Map


HetResidual Block
Feature Map
Multi-scale Features
Single-scale Features
Residual Block

Gradient Function



The gradient variation between pixels are significant !

The gradient between pixel does not shift clearly...

Let's try using the gradient as a loss function !

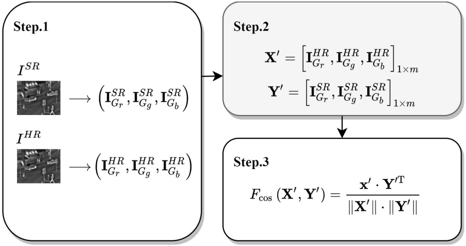
Gradient Cosine Similarity Loss Function

- We chose the gradient of the image as the feature that measures the similarity between the two images.

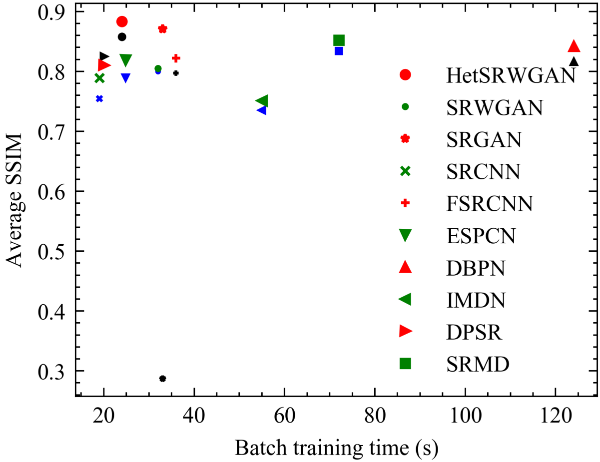
Algorithm 1 Gradient Cosine Similarity Loss Function

Input: I^{SR}, I^{HR}
Output: Gradient Cosine Similarity

Infrared images can be processed into RGB images.
while not convergent **do**
  $I^{HR} \longrightarrow \left(\mathbf{I}_{G_r}^{HR}, \mathbf{I}_{G_g}^{HR}, \mathbf{I}_{G_b}^{HR}\right)$
  $I^{SR} \longrightarrow \left(\mathbf{I}_{G_r}^{SR}, \mathbf{I}_{G_g}^{SR}, \mathbf{I}_{G_b}^{SR}\right)$
  $\mathbf{X}' = \left[\mathbf{I}_{G_r}^{HR}, \mathbf{I}_{G_g}^{HR}, \mathbf{I}_{G_b}^{HR}\right]_{1\times m}$
  $\mathbf{Y}' = \left[\mathbf{I}_{G_r}^{SR}, \mathbf{I}_{G_g}^{SR}, \mathbf{I}_{G_b}^{SR}\right]_{1\times m}$
  $F_{\cos}\left(\mathbf{X}', \mathbf{Y}'\right) = \frac{\mathbf{X}' \cdot \mathbf{Y}'^{\mathrm{T}}}{\|\mathbf{X}'\| \cdot \|\mathbf{Y}'\|}$
return $F_{\cos}\left(\mathbf{X}', \mathbf{Y}'\right)$



Experimental Results (HetSRWGAN)



Qualitative Results (HetSRWGAN)

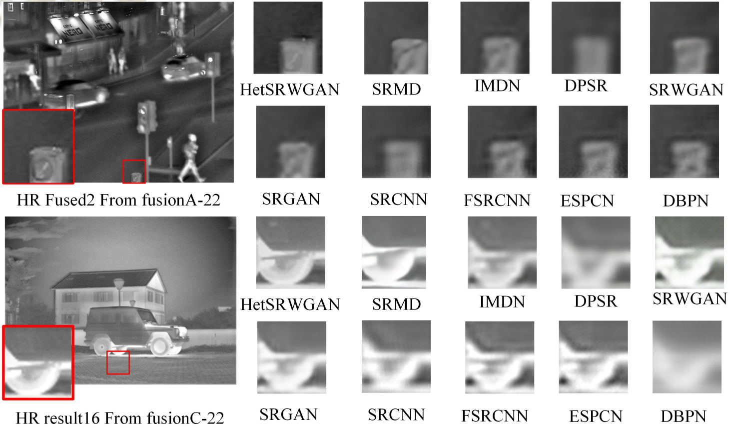
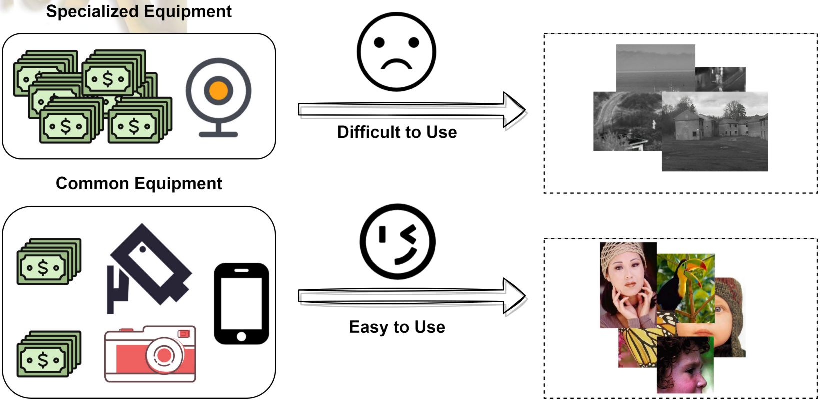
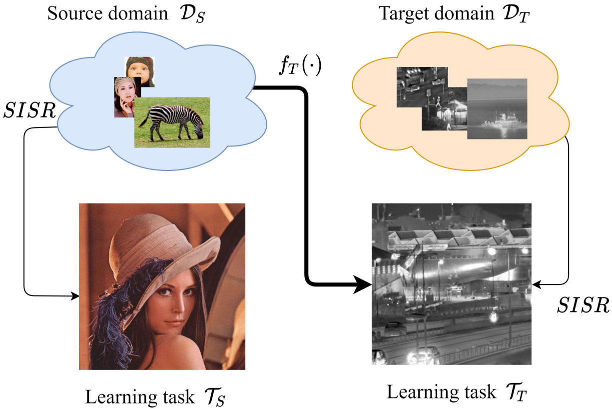


Image Data Dilemma



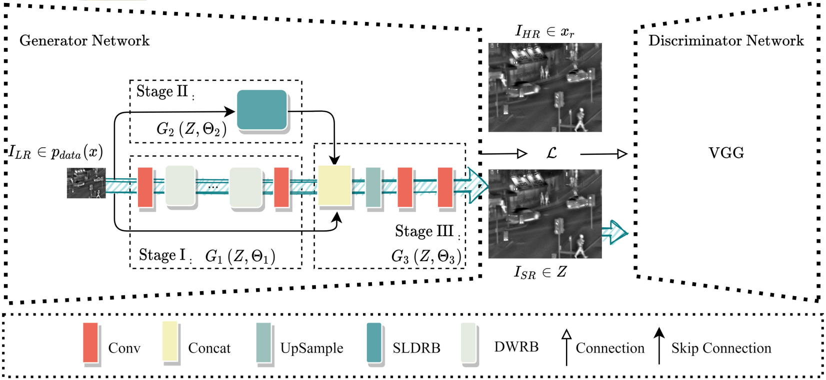
Transfer Learning



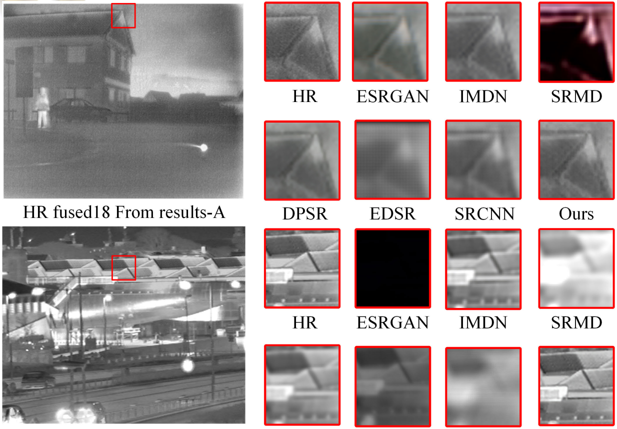
Transfer Learning: predictive function $f_T(\cdot)$

$$\mathcal{D}_S \neq \mathcal{D}_T \text{ or } \mathcal{T}_S \neq \mathcal{T}_T$$

PSRGAN Architecture



Qualitative Results (PSRGAN)



HR fused18 From results-A

HR result21 From results-C

Reference

- Huang Y., Jiang Z., Wang Q., Jiang Q., Pang G. (2021) Infrared Image Super-Resolution via Heterogeneous Convolutional WGAN. In PRICAI 2021: Trends in Artificial Intelligence. PRICAI 2021. Lecture Notes in Computer Science, vol 13032. Springer, Cham.
- Y. Huang, Z. Jiang, R. Lan, S. Zhang and K. Pi, "Infrared Image Super-Resolution via Transfer Learning and PSRGAN," in IEEE Signal Processing Letters, vol. 28, pp. 982-986, 2021.

Thank you for watching!

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