Super Resolution summary

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Artificial Intelligence & Information Analysis Lab

Super Resolution

Introduction

VML

- **Super Resolution (SR)** is a class of techniques that focus on generating a higher – resolution (HR) image from one or multiple lower – resolution (LR) observed ones, with the size of the input and output being the same, but with the quality of the latter improved.

- SR offers solutions to the demand of HR images, which arises mainly from the need of improvement of visual information for human perception, and the task of achieving the best possible representation, for automatic machine perception.

- SR has found application in satellite, medical and microscope image processing, text image analysis, multimedia enhancement, object detection, real time processing and many more [2].

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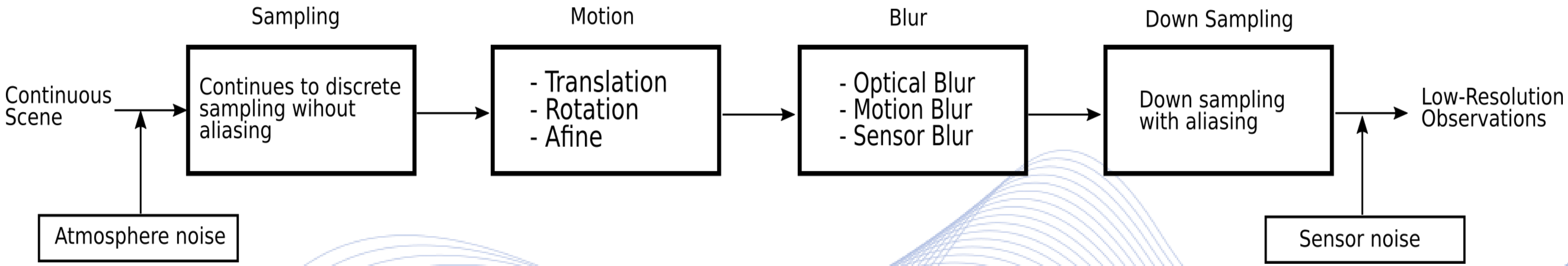
Multi-Image Super Resolution



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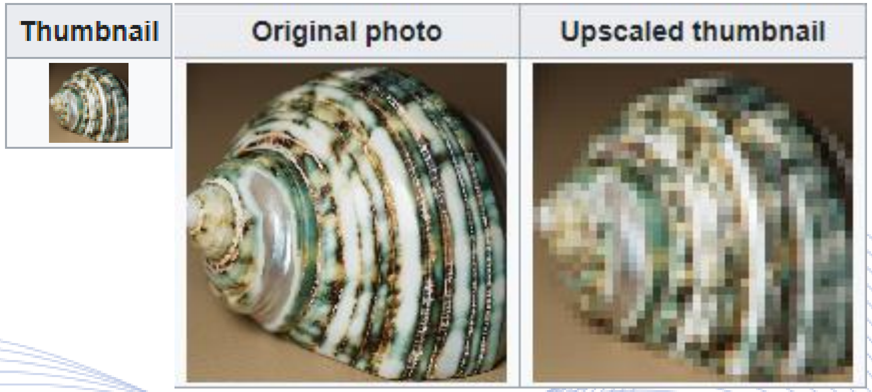
Nearest Neighbor Interpolation



Upscaled Image with NN method {Image from [wiki:5]}

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Bicubic Interpolation

- **Bicubic Interpolation** goes one step beyond bilinear by considering the closest 4x4 neighborhood of known pixels — for a total of 16 pixels. Since these are at different distances from the unknown pixel, closer ones are given a higher weighting in the calculation. Bicubic produces notably sharper images than the previous algorithms and is perhaps the optimal combination of processing time and output quality. [wiki:4]

Bicubic Interpolation

[A] Original

[B] Nearest Neighbor

[C] Bilinear Interpolation

[D] Bicubic Interpolation

Image from [Ashish Kothari_2014]

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Deep Learning Methods

- **Deep Learning Methods (DL)** have proved to be very promising in Image Processing. They are being used in tasks such as classification, segmentation, denoising, solving inverse problems etc. This approach to Image Processing is characterized by two main aspects: refined parallel calculation and impressive representation ability.

- It is important to note however, that a DL model's efficiency is proportional to the amount of training data that are being used. [6]

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Deep Convolutional Neural Networks

- We plan to recover an image $F(Y)$ that is as similar as possible to the HR image X. The mapping F, consists of [7]:
  1. Patch extraction and representation
  2. Non-Linear mapping
  3. Reconstruction

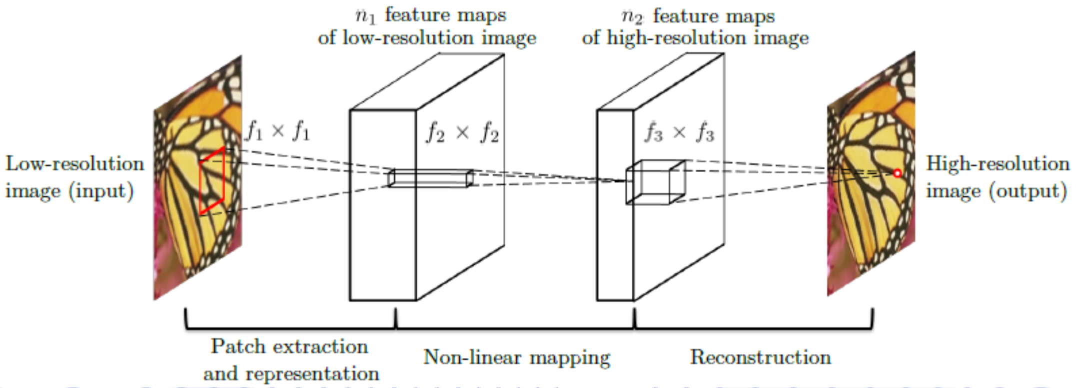

Image from [7]

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Signal Fidelity Measures

- **Signal Fidelity Measures** are functions/metrics which are used to compare signals, by producing a value of similarity between them.

- MSE is widely used since it has many advantages over other metrics. Some of them are: It's simplicity/low complexity, as it's clear physical meaning.

- However, since it only computes pixel-wise differences and does not provide any information about the contents of an image, it does not produce optimal outputs when it is used to predict human perception of image fidelity and quality. [9]

Signal Fidelity Measures

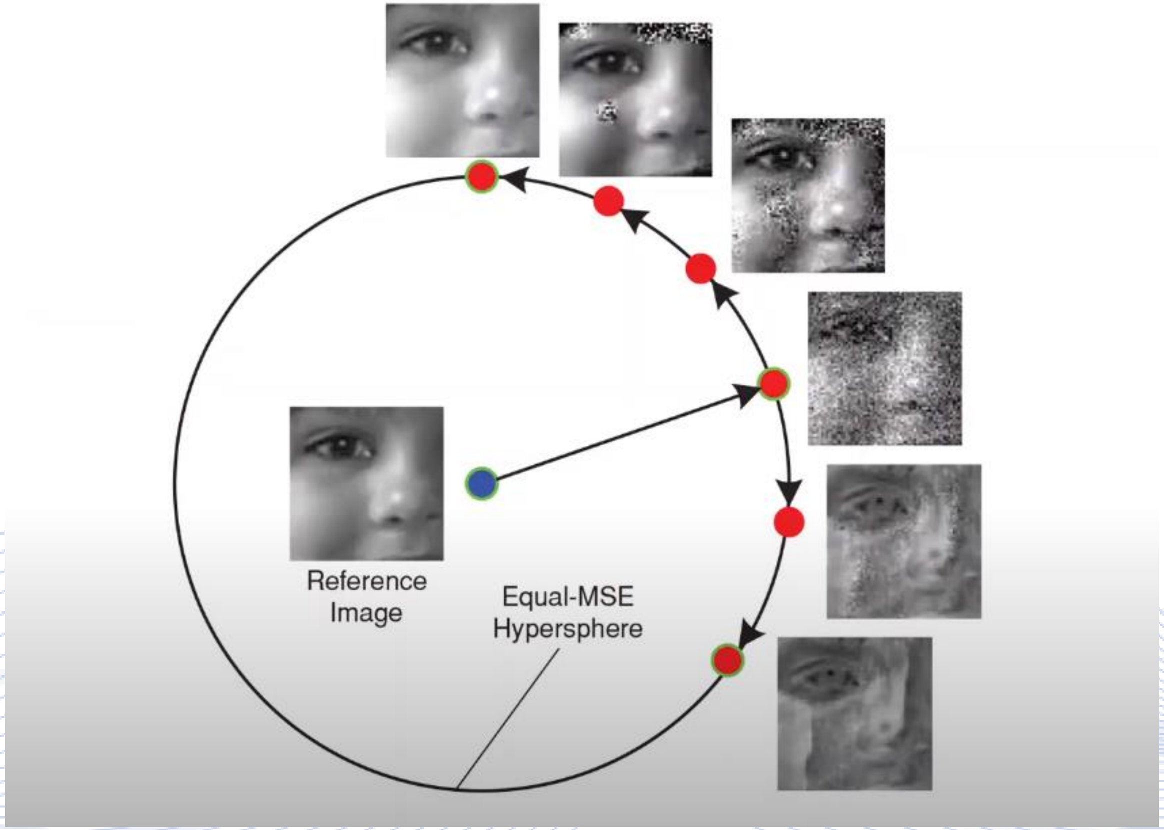


Image from [8]

Signal Fidelity Measures

- A better preforming metric of perceptual image quality is the **Structural Similarity Index Measure (SSIM).** SSIM was initially developed to measure the severity of image degradation, however SSIM is also used in research as a Loss Function to train NNs for Image Restoration. [9]

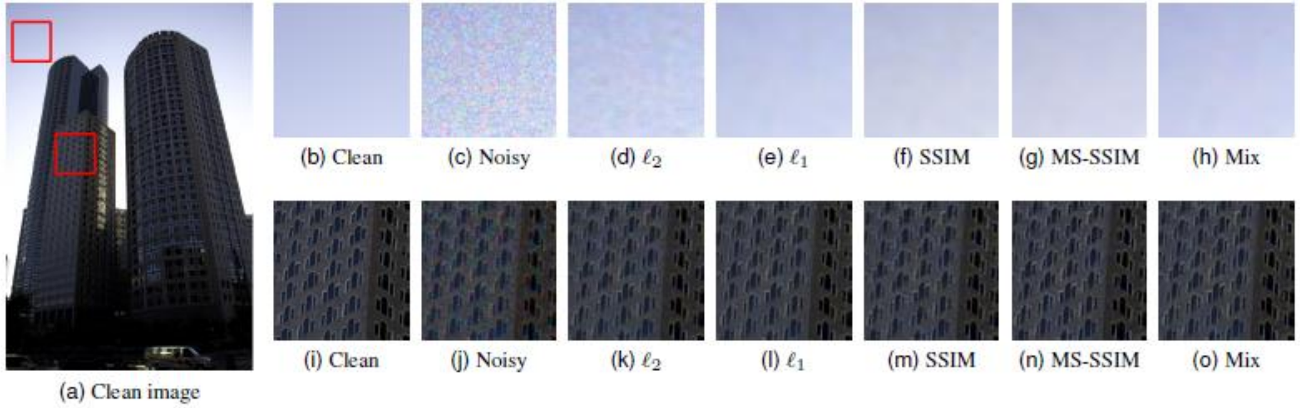
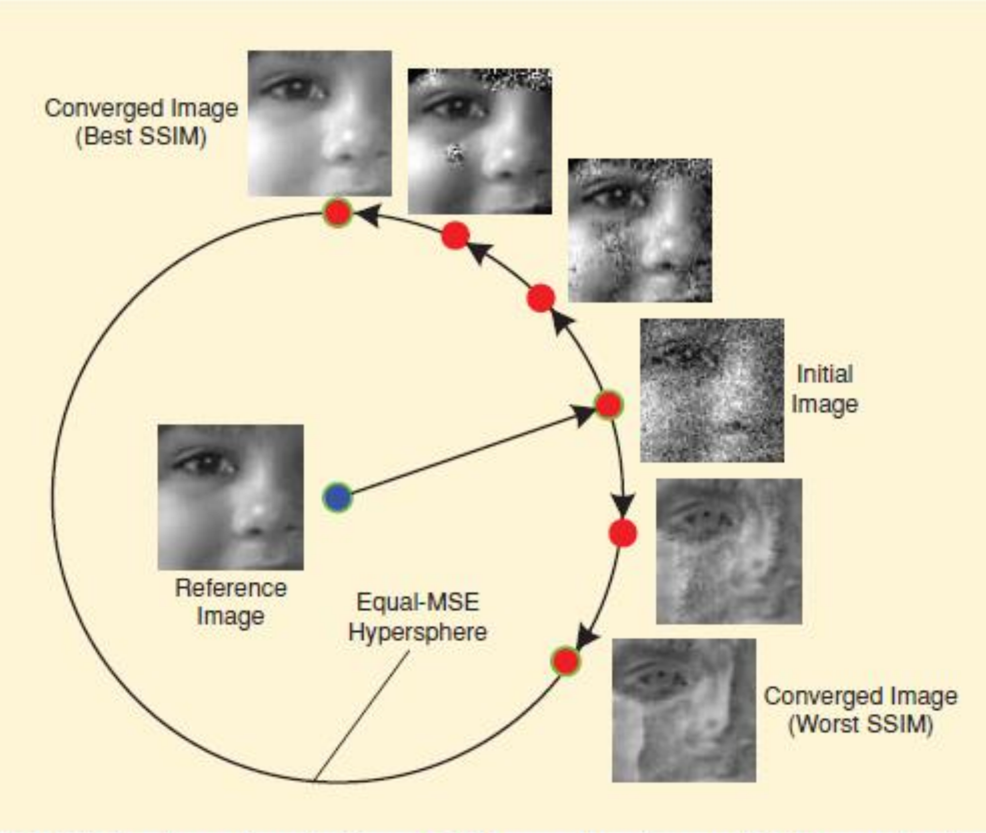


Fig. 1: Comparisons of the results of joint denoising and demosaicking performed by networks trained on different loss functions (best viewed in the electronic version by zooming in). ℓ_2, the standard loss function for neural networks for image processing, produces splotchy artifacts in flat regions (d).

Image from [9]

Signal Fidelity Measures



[FIG4] Finding the maximum/minimum SSIM images along the equal-MSE hypersphere in image space.

Image from [16]

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Generative Adversarial Networks

- A **Generative Adversarial Network (GAN)** is a class of machine learning framework [goodfellow], which consists of 2 NNs (“generative” and “discriminative”) contesting each other in a zero-sum game.

- The **Generative Network (GN)** generates candidates while the **Discriminative Network (DN)** distinguishes them from the true data distribution. The GN’s objective is to increase the error rate of the DN.

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Super Resolution GANs

- **Super Resolution Generative Adversarial Network (SRGAN) [10]** is a GAN - based network where the MSE - based content loss is replaced by **Perceptual Loss Function (PLF)** . PLF is expressed as:

$$l^{SR} = l_x^{SR} + 10^{-3} l_{Gen}^{SR}$$

- l_x^{SR} : Content loss, defined based on the ReLU activation layers of the VGG-19 [14].
- $10^{-3} l_{Gen}^{SR}$: Adversarial Loss

- The GN has B residual blocks with identical architecture. Each block is comprised of two convolutional layers with 3x3 kernels and 64 feature maps succeeded by batch-normalization layers and ParametricReLU as the activation function.

Super Resolution GANs

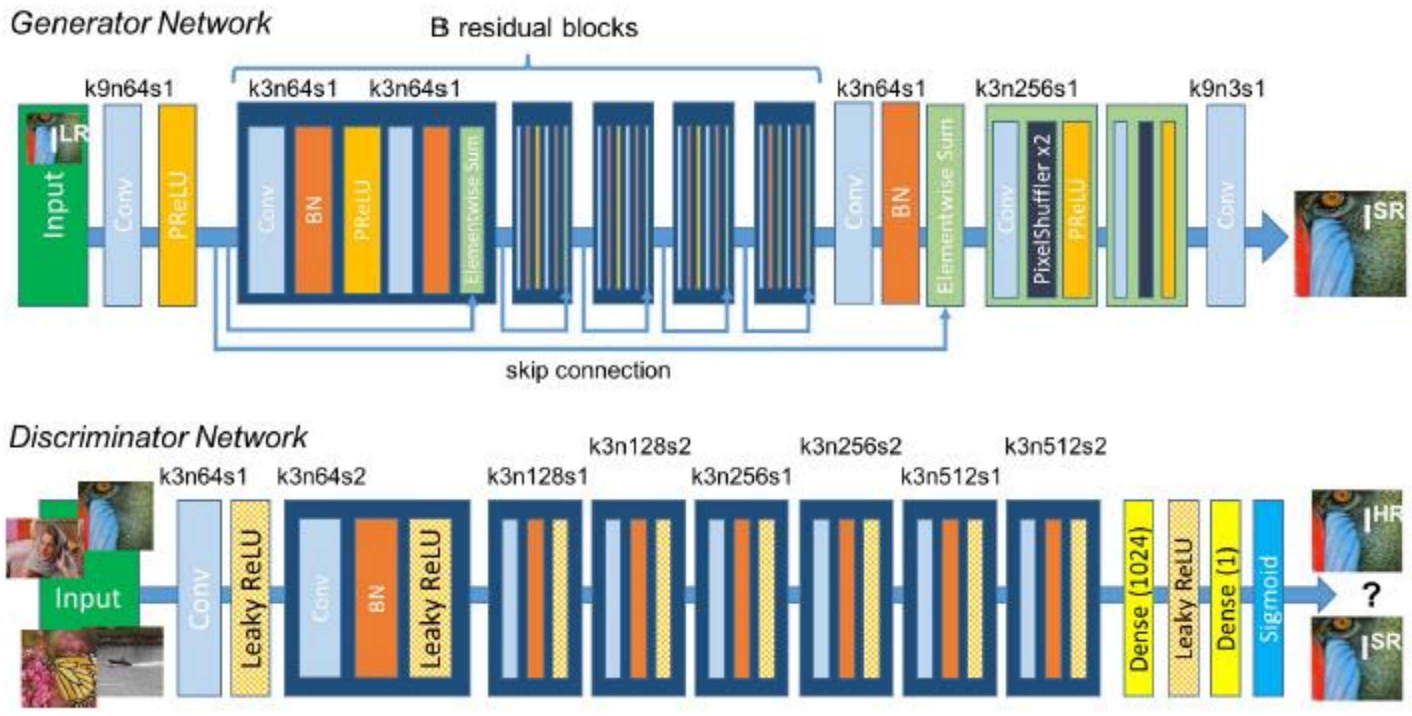

Figure 4: Architecture of Generator and Discriminator Network with corresponding kernel size (k), number of feature maps (n) and stride (s) indicated for each convolutional layer.

Image from [10]

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Enhanced SRGANs

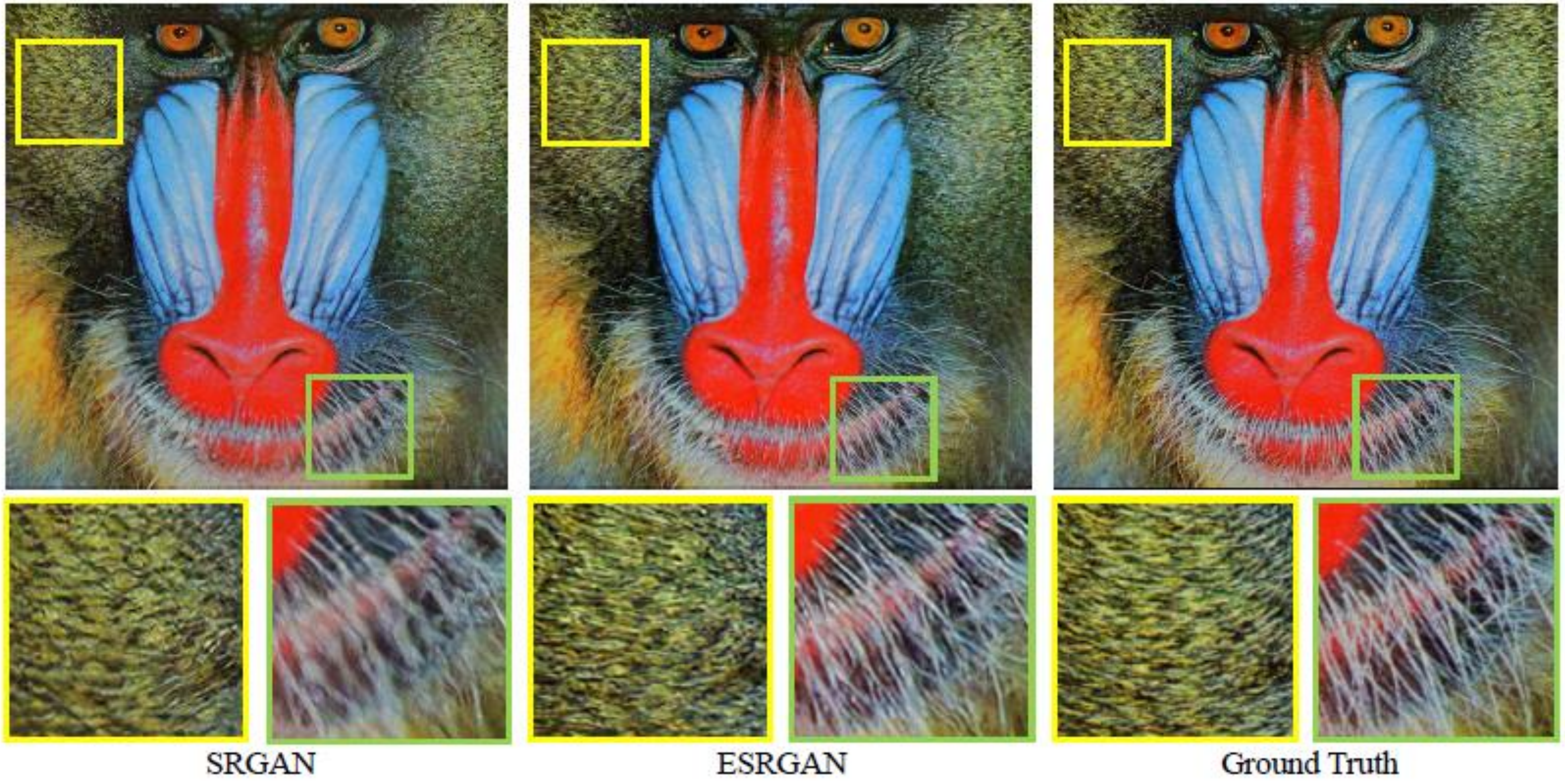

Fig. 1: The super-resolution results of $\times 4$ for SRGAN[2], the proposed ESRGAN and the ground-truth. ESRGAN outperforms SRGAN in sharpness and details.

Image from [11]

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MISR with Residual Attention Network

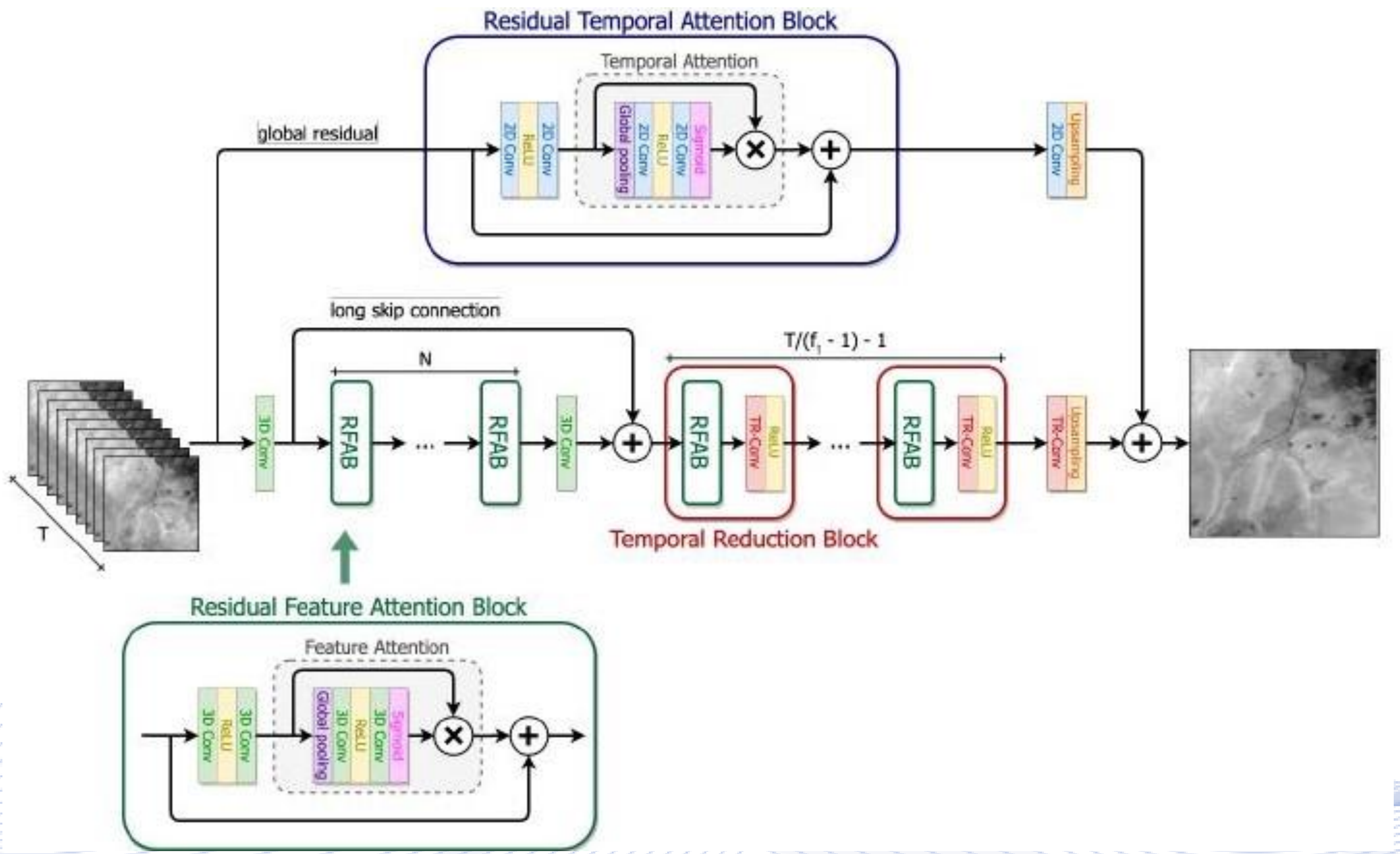

Image from [15]

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Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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