Perceptually-Optimized Loss Function for Image Super-Resolution

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Outline

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What is *Super-Resolution*?

- increasing the dimension

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  - input $(X_{M \times N})$ $\xrightarrow{\text{upsampling by a factor of 2 (i.e. } 2\uparrow)}$ output $(Y_{2M \times 2N})$
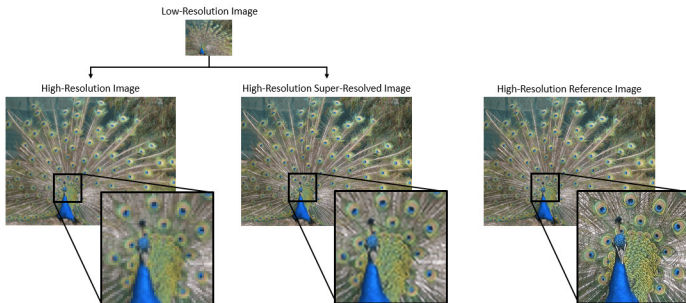
What is *Super-Resolution*?

- increasing the dimension
  - input $(X_{M \times N})$ $\xrightarrow{\text{upsampling by a factor of 2 (i.e. } 2\uparrow)}$ output $(Y_{2M \times 2N})$
  - BiLinear, BiCubic, etc.

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- **!! Preserving the quality !!**

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- **!! Preserving the quality !!**

CNNs and Loss Functions

- Super-Resolver CNNs
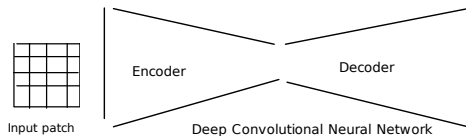
CNNs and Loss Functions
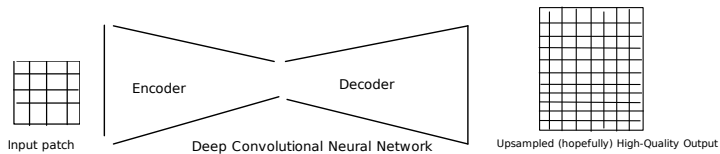
- Super-Resolver CNNs

Input patch

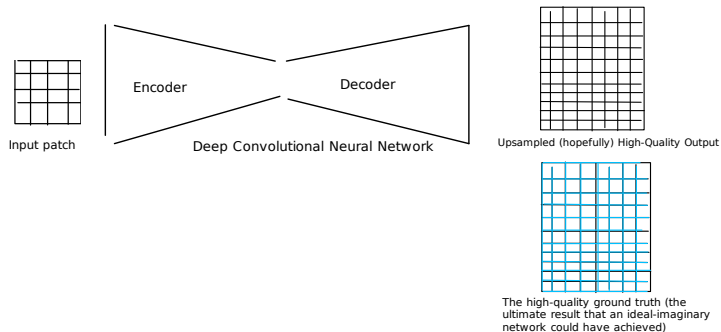# CNNs and Loss Functions

- Super-Resolver CNNs

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Input patch   Encoder   Decoder   Deep Convolutional Neural Network   Upsampled (hopefully) High-Quality Output

CNNs and Loss Functions

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Input patch

Encoder

Decoder

Deep Convolutional Neural Network

Upsampled (hopefully) High-Quality Output

The high-quality ground truth (the ultimate result that an ideal-imaginary network could have achieved)

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  - $Y = F(X, W)$

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  The amount of update that must be applied to W $(i.e. \Delta W) = E(Y, \hat{Y})$;
  where $E \in [0, 1]$

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  $Y = F(X, W)$
  The amount of update that must be applied to W $(i.e.\Delta W) = E(Y, \hat{Y})$;
  where $E \in [0, 1]$
  The updated network's weights $(i.e. W\prime) = W + \Delta W$

CNNs and Loss Functions

- Super-Resolver CNNs

- The Loss Function
  How to define $E(Y, \hat{Y})$?

Ways to Define a Loss Function

# Ways to Define a Loss Function

- Visible Error

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$$E(Y, \hat{Y}) = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} (Y(i,j) - \hat{Y}(i,j))^2$$
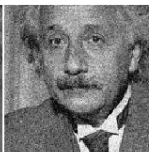
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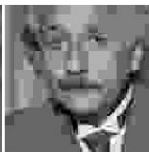- Quality Metrics
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Ways to Define a Loss Function

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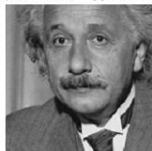$$E(Y, \hat{Y}) = SSIM(Y, \hat{Y})$$
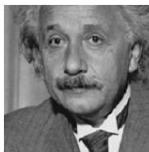
(a) MSE=0, SSIM=1   (b) MSE=309, SSIM=0.576   (c) MSE=308, SSIM=0.641   (d) MSE=309, SSIM=0.580

(e) MSE=871, SSIM=0.404
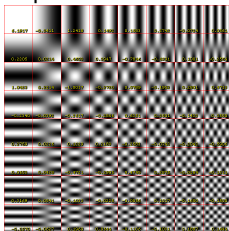
Our Approach

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- DCT

Our Approach
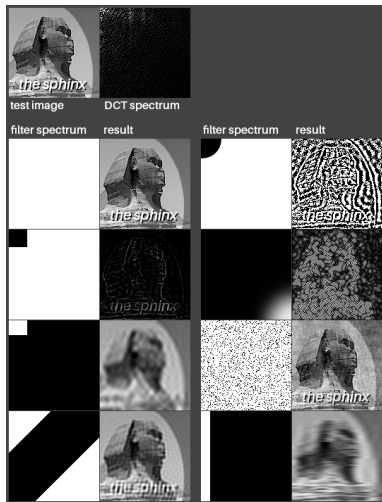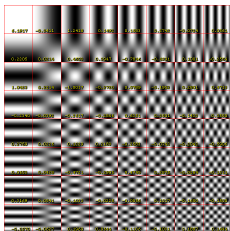
- DCT
  - Expressive

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- DCT
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  - Fast!

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- Further Purification