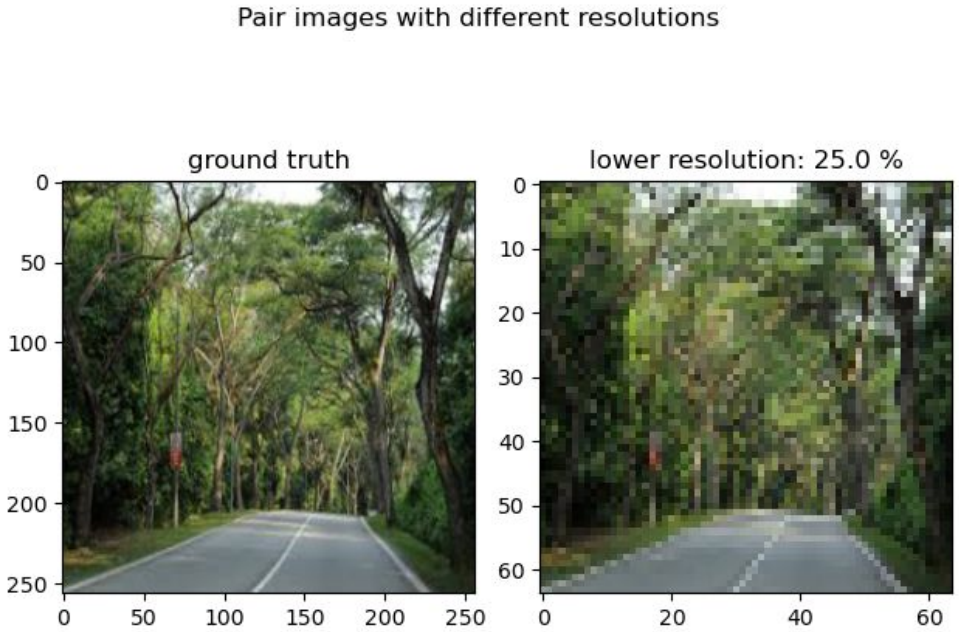
# Image Super-Resolution

Ignatius S. Condro Atmawan
saptocondro@gmail.com

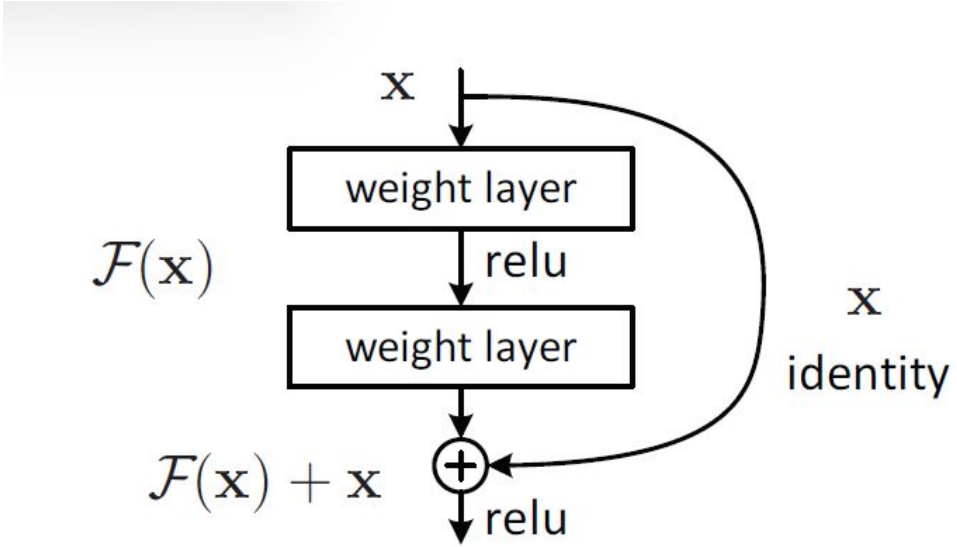
# Motivation




- To transform image with low resolution into plausible image with higher resolution
- Possible usage: astronomy, medical imaging, security camera, fun filter for social media, etc

# Residual Neural Network

- Skip connection
- Batch Normalization
- RELU




Source: He, et al, 2015, “Deep Residual Learning for Image Recognition”, Microsoft Research, link: https://arxiv.org/abs/1512.03385

# Convolutional Neural Network Model

- Upscaling, e.g. Convolutional Transpose (Conv2DTranspose)
- Blocks of Residual Neural Network
- CNN layer (Conv2D) as output

- Metrics: MSE, MAE, PSNR, SSIM
- Adam optimizer for model fitting/learning

- Data from: https://www.kaggle.com/datasets/adityachandrasekhar/image-super-resolution/data
- After loading images from the data, downscaling is conducted, to simulate image with lower resolution
- 685 train images & 170 test images

# Peak Signal-to-Noise Ratio (PSNR)

$$MSE = \frac{1}{m\,n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2.$$

The PSNR (in dB) is defined as

$$\begin{aligned} PSNR &= 10 \cdot \log_{10} \left( \frac{MAX_I^2}{MSE} \right) \\ &= 20 \cdot \log_{10} \left( \frac{MAX_I}{\sqrt{MSE}} \right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE). \end{aligned}$$

Source: https://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio

# Structural Similarity Index Measure (SSIM)

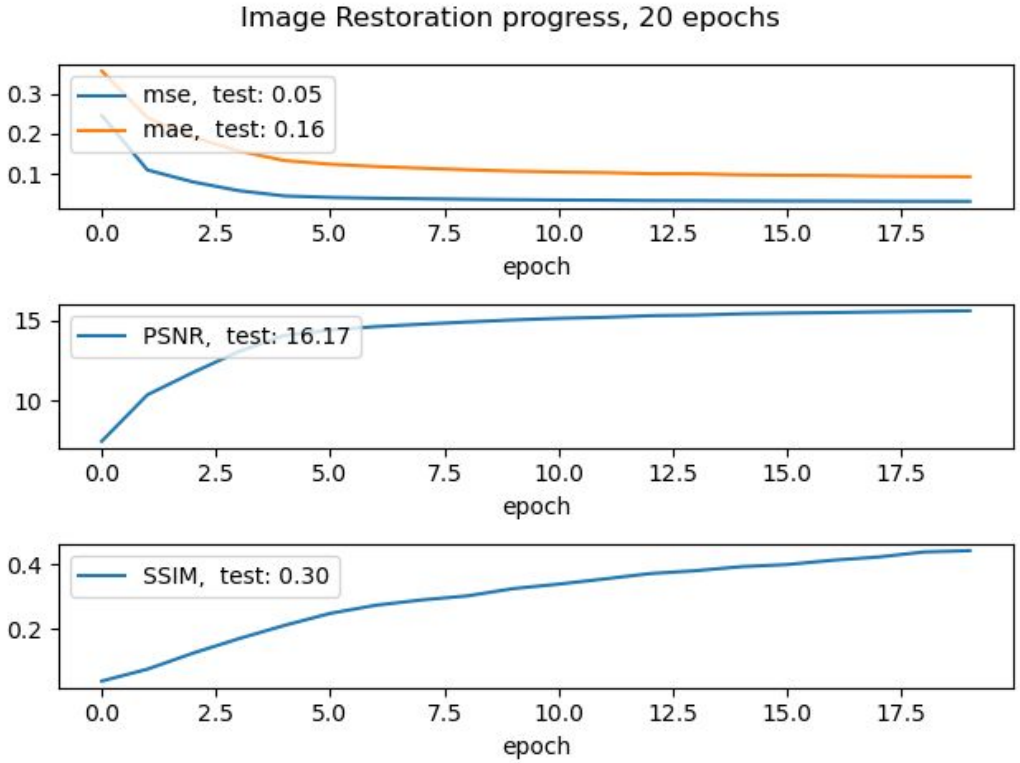
$$\mathrm{SSIM}(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

with:

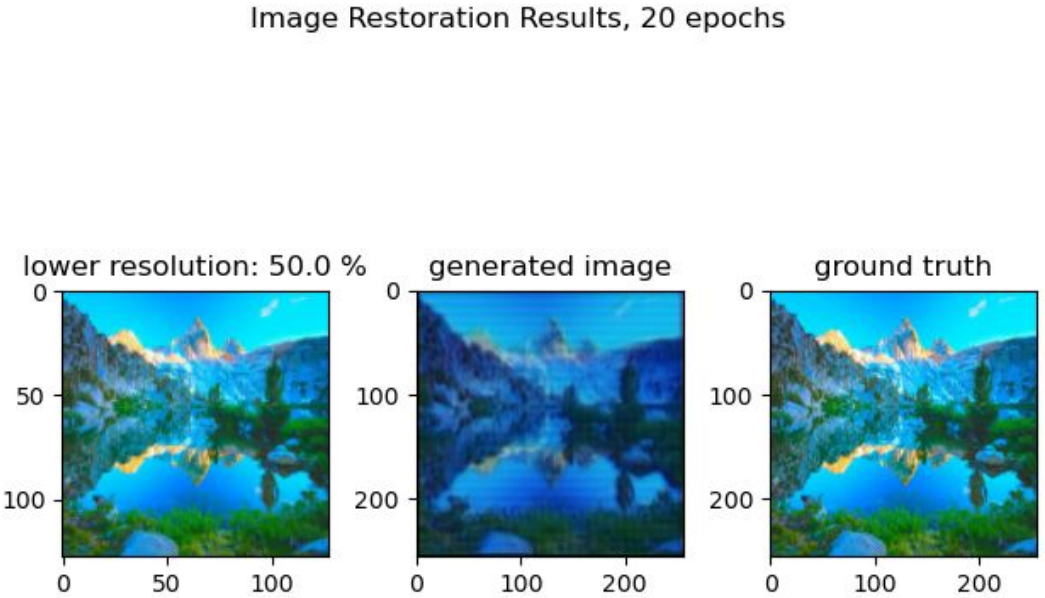
- $\mu_x$ the pixel sample mean of $x$;
- $\mu_y$ the pixel sample mean of $y$;
- $\sigma_x^2$ the variance of $x$;
- $\sigma_y^2$ the variance of $y$;
- $\sigma_{xy}$ the covariance of $x$ and $y$;
- $c_1 = (k_1 L)^2$, $c_2 = (k_2 L)^2$ two variables to stabilize the division with weak denominator;
- $L$ the dynamic range of the pixel-values (typically this is $2^{\#bits\ per\ pixel} - 1$);
- $k_1 = 0.01$ and $k_2 = 0.03$ by default.

Source: https://en.wikipedia.org/wiki/Structural_similarity

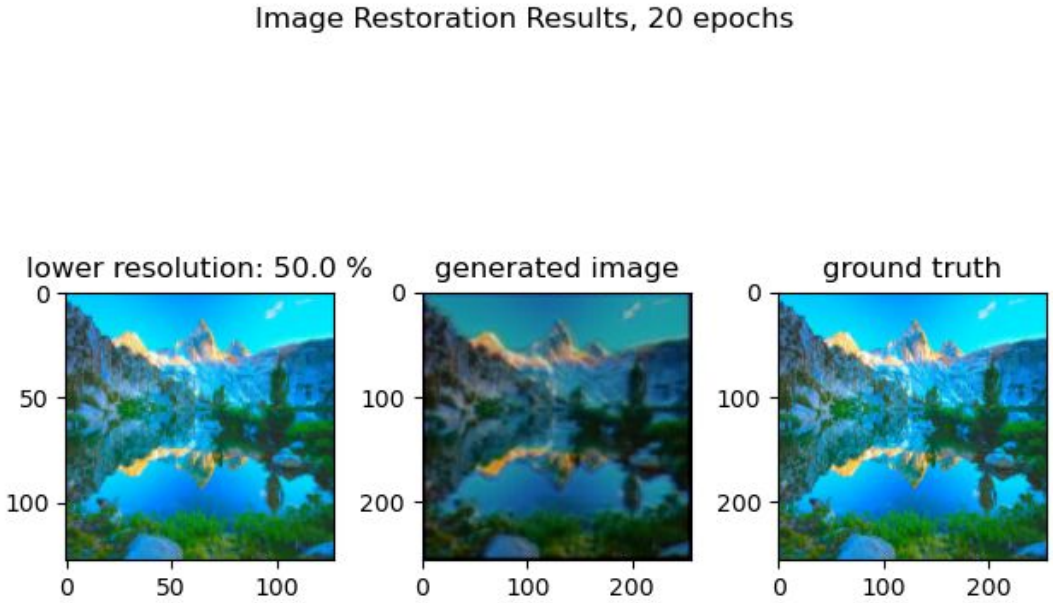
# Model Evaluation: 50% downscale, 2 residual blocks



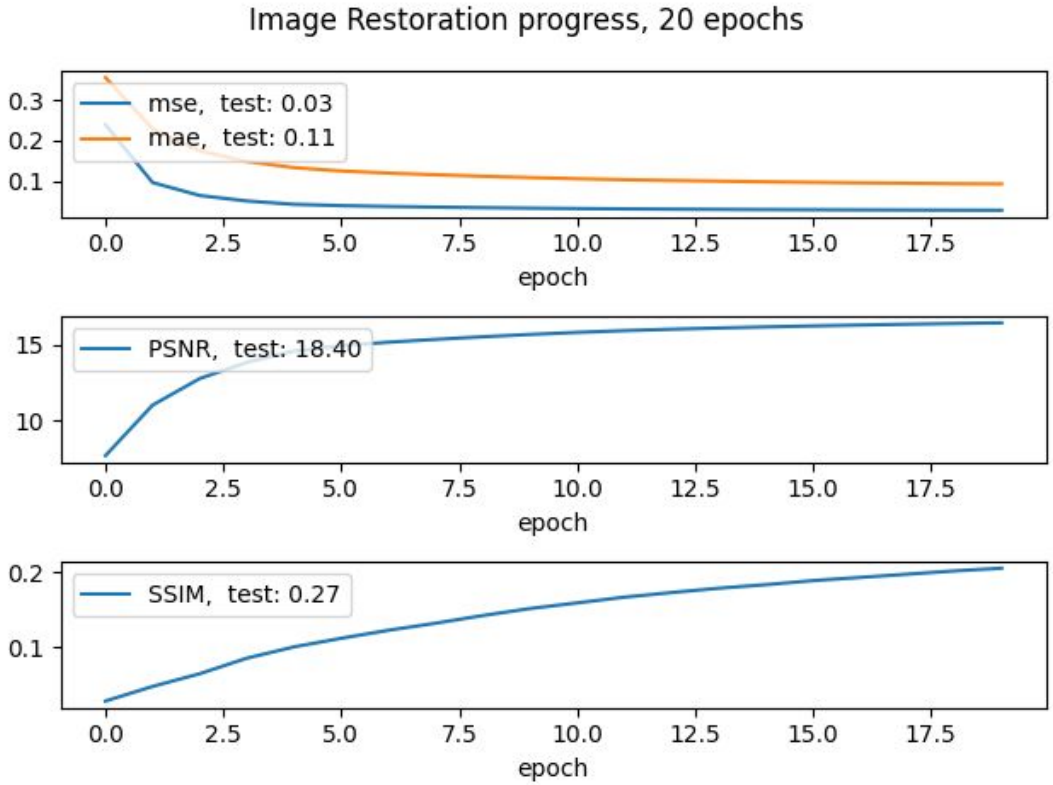
# Results of Image Reconstruction: 50% downscale, 2  residual blocks



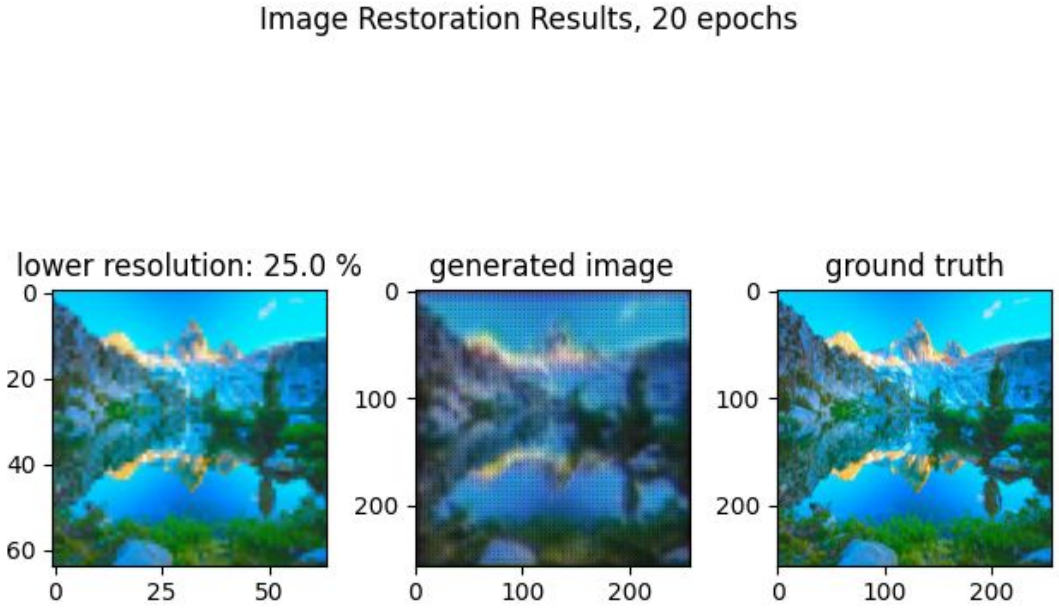
# Results of Image Reconstruction:
# 50 % downscale, 1 residual blocks



# Model Evaluation: 25% downscale, 2 residual blocks



# Results of Image Reconstruction:
# 25 % downscale, 2 residual blocks



# Discussion & Conclusion

- Image can be reconstructed with CNN-model, from lower resolution. Here is from the downscale of 25% and 50%
- The PSNR of current existing models are above 30 dB, but the results from my model rarely achieved 20 dB
- The SSIM of current existing models are above 0.65, but the results from my model never achieved 0.5

  Link: https://www.researchgate.net/figure/Comparison-of-PSNR-and-SSIM-values-of-image-reconstruction-by-eight-methods_tbl2_352702087

- CNN-model takes time in personal computer/laptop. It is better to use high performance computers, for example in the cloud