## Interpreting Neural Networks in Artistic Style Transfer

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#### Intro

Gatys et. al. introduce a framework using CNNs to create artistic images by separating and recombining the content and style of images. They also more generally explain how DNNs can be used for texture synthesis and style transfer. Following their framework:

- CNNs encode content and style information in ways which are separable
- **Content** is captured in the higher layers of the CNN, retaining object structures but not fine pixel details
- Style is represented by the correlations between feature responses across multiple layers.

This system allows for the recombination of content and style from two different images to generate new artistic images.

# Overview of Mathematics

# Content Representation $L_{content}(\vec{p}, \vec{x}, l) = \frac{1}{2} \sum_{i,j} (F_{ij}^l - P_{ij}^l)^2$

Content is represented using the feature maps from the pretrained model. F and P are of dimensions N \* M

### Style Representation

Gram matrix Calculation:

$$G_{ij}^l = \sum_k F_{ik}^l F_{jk}^l$$

Gram Matrix calculates correlation between feature Maps

Go to demo

### Style Loss

We then calculate the Gram matrices of the Style image, and the generated image, and find MSE of the difference of these two matrices.

$$E_{l} = \frac{1}{4N_{l}^{2}M_{l}^{2}} \sum_{i,j} (G_{ij}^{l} - A_{ij}^{l})^{2}$$

Then we sum over all Layers:

$$L_{style}(\vec{a}, \vec{x}) = \sum_{l=0}^{L} w_l E_l$$

## Why Across All Layers?

Calculating Style loss over multiple layers allows for more robust style transfer, as different layers capture different levels of visual information. Lower might cover brushstroke, texture. Middle might cover swirls and patterns. Higher might cover structures.

Weights can be adjusted on a per layer basis.

#### Loss Function and Optimization

$$L_{total}(\vec{p}, \vec{a}, \vec{x}) = \alpha L_{content}(\vec{p}, \vec{x}) + \beta L_{style}(\vec{a}, \vec{x})$$

$$\vec{x} \leftarrow \vec{x} - \eta \nabla_{\vec{x}} L_{total}$$

### Bibliography

Gatys, Leon A., et al. "A Neural Algorithm of Artistic Style." *arXiv.Org*, 2 Sept. 2015, arxiv.org/abs/1508.06576v2.

Developers Hutt. (n.d.). Why Gram Matrix in Style Transfer || Quick Explained. https://www.youtube.com/watch?v=Elxnzxk-AUk