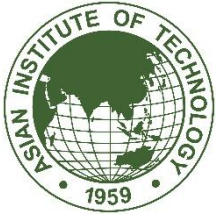



# Neural Style Transfer

Dr. Mongkol Ekpanyapong

# What is Style Transfer?

# Example

A Neural Algorithm of Artistic Style

Leon A. Gatys,[1,2,3*] Alexander S. Ecker,[1,2,4,5] Matthias Bethge[1,2,4]

# Terminology

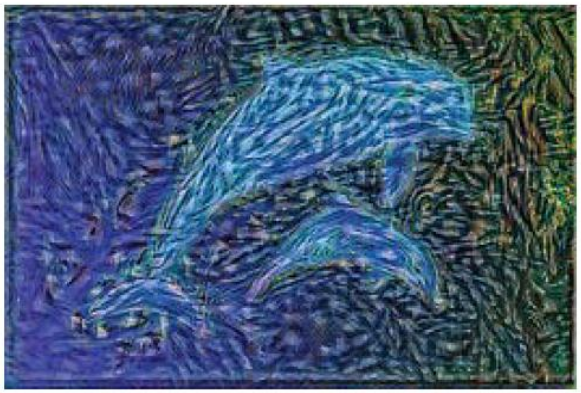
Content image

+

Style image

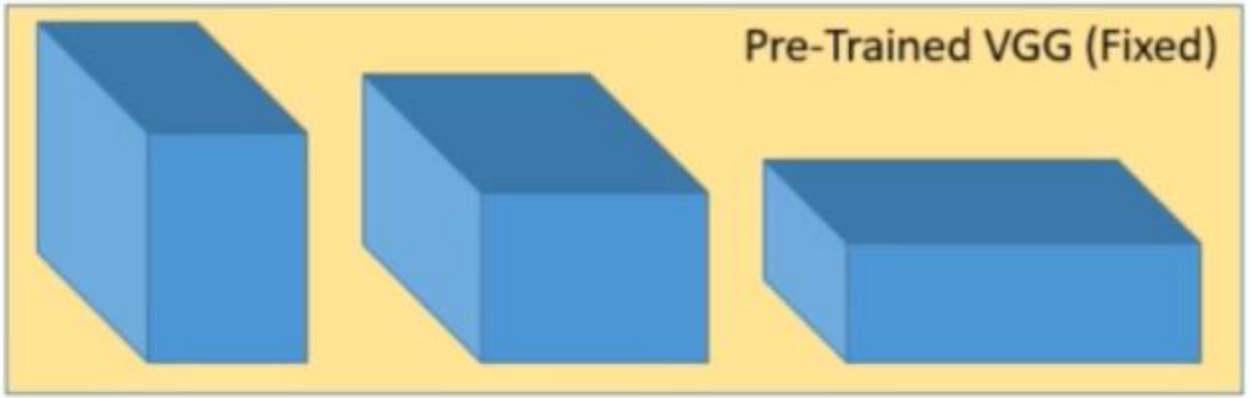
=

Combined image

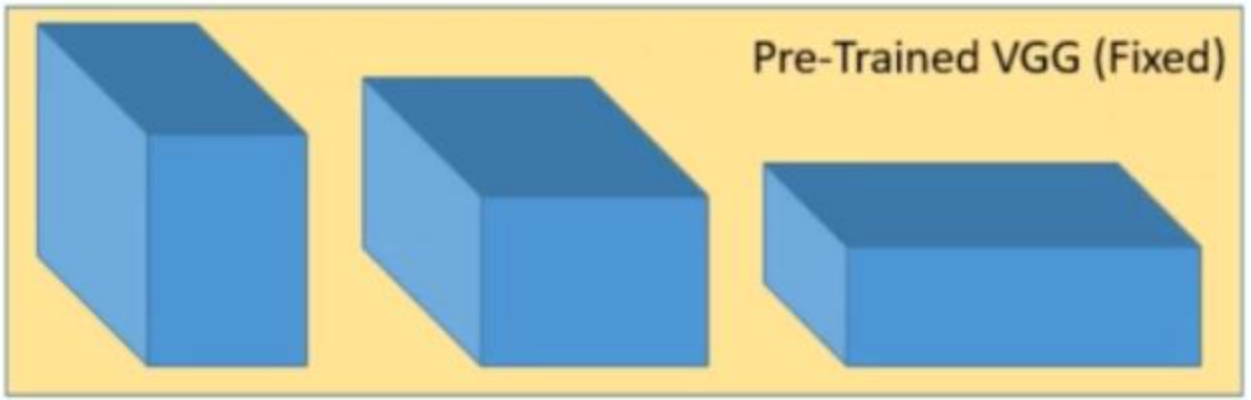


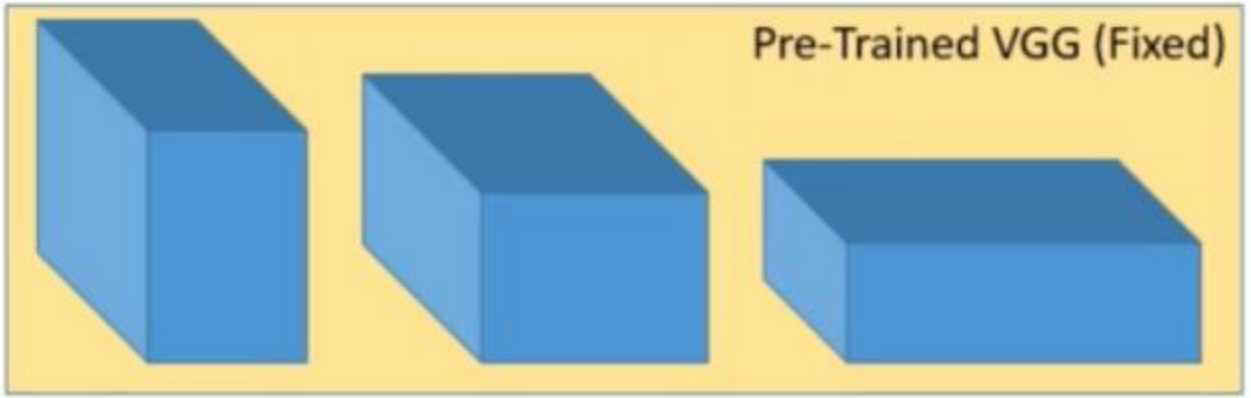
# Algorithm

- Import and freeze a pretrained CNN
- Import a content and style images
- Make a trainable target image
- Computer feature maps
- Extract feature mapes
  - Compute contentMSE: target vs. content image
  - Compute styleMSE: Gram(target) vs. style image
  - Compute Loss = $\alpha$ contentMSE loss + $\beta$ style MSE loss
  - Compute back propagation on Target Image




**Weights to Update** (Image)



# Loss function

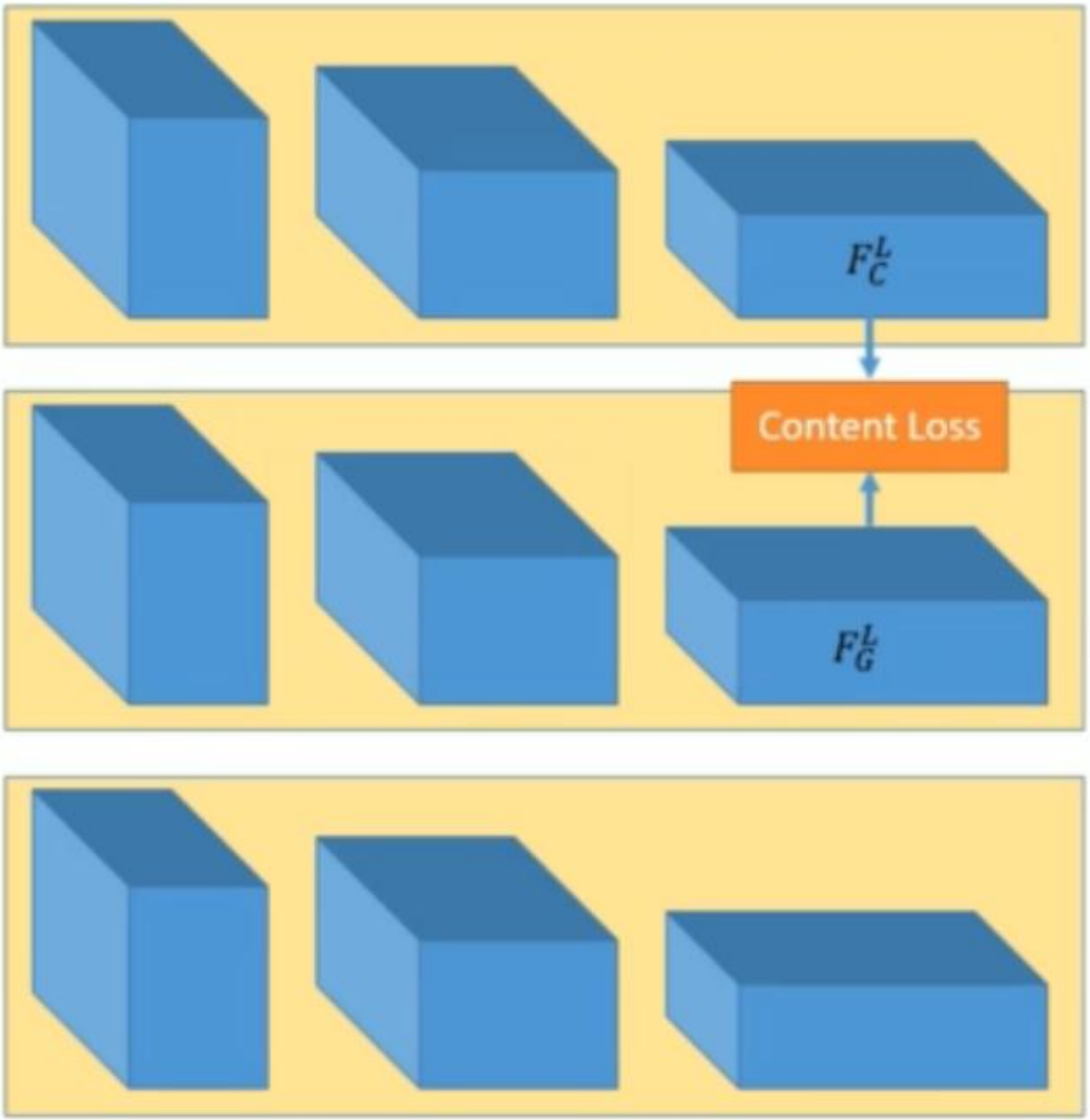
- Content Loss: We want to transfer the content image into the target image

- Style Loss: We want the style of the style image to be similar to the targe image

# Content Loss

- Content loss is used to compared between the final feature vector of content image and target image

- Mean Square error could be used




***Mean Squared Error*** between the last feature maps of the content image and the generated image

→ Copy content to generated image

$$\frac{1}{n}\sum(F_C^L - F_G^L)^2$$

# Style Loss

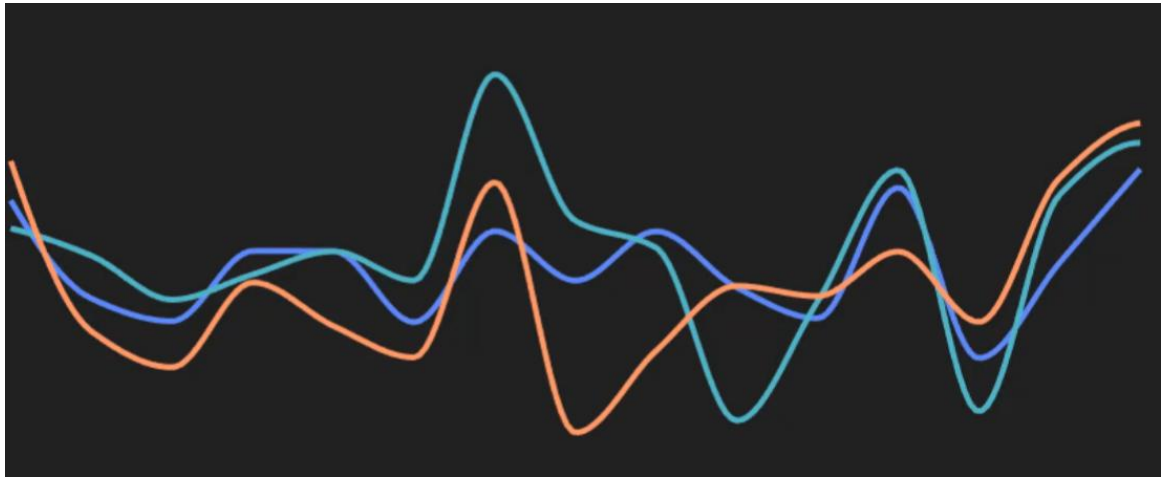
- Style loss is applied on many layers between style image and target image

- Gramm matrix: a kind of correlation matrix is used

$$Gram = MM^T$$

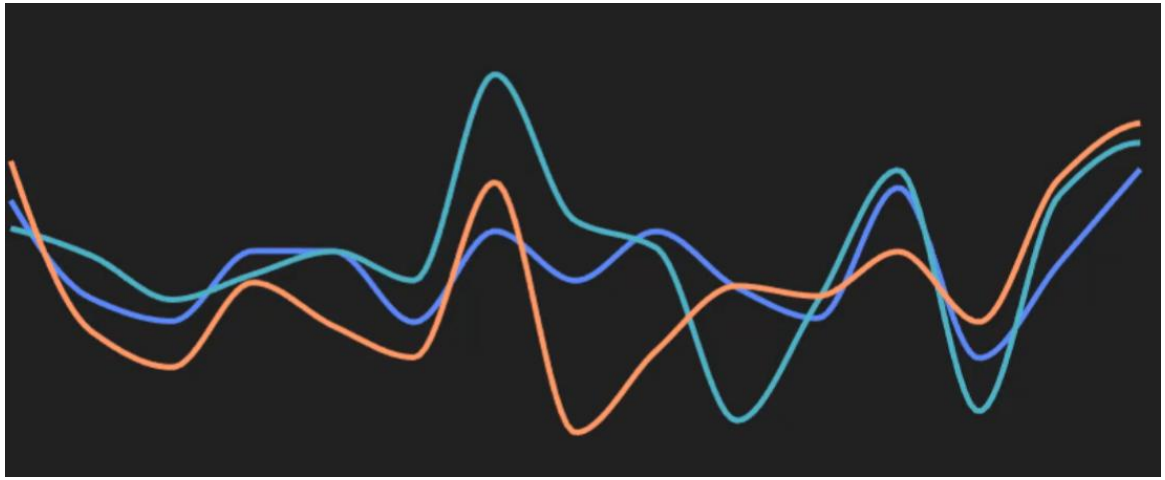
$$\underset{M}{\begin{matrix}19 & 20\\ 9 & 8\end{matrix}} \cdot \underset{M^T}{\begin{matrix}19 & 9\\ 20 & 8\end{matrix}} = \begin{matrix}761 & 331\\ 331 & 145\end{matrix}$$

# Correlation Matrix



| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 1 | .67 | .51 |
| 2 | .67 | 1 | .41 |
| 3 | .51 | .41 | 1 |

# Covariance Matrix



| | 1 | 2 | 3 |
|---|---|---|---|
| 1 | 3.16 | 4.13 | 2.79 |
| 2 | 4.13 | 11.79 | 4.32 |
| 3 | 2.79 | 4.32 | 9.31 |

# Equations

- Covariance metric

$$c = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \overline{x})(y_i - \overline{y})$$

- Correlation metric

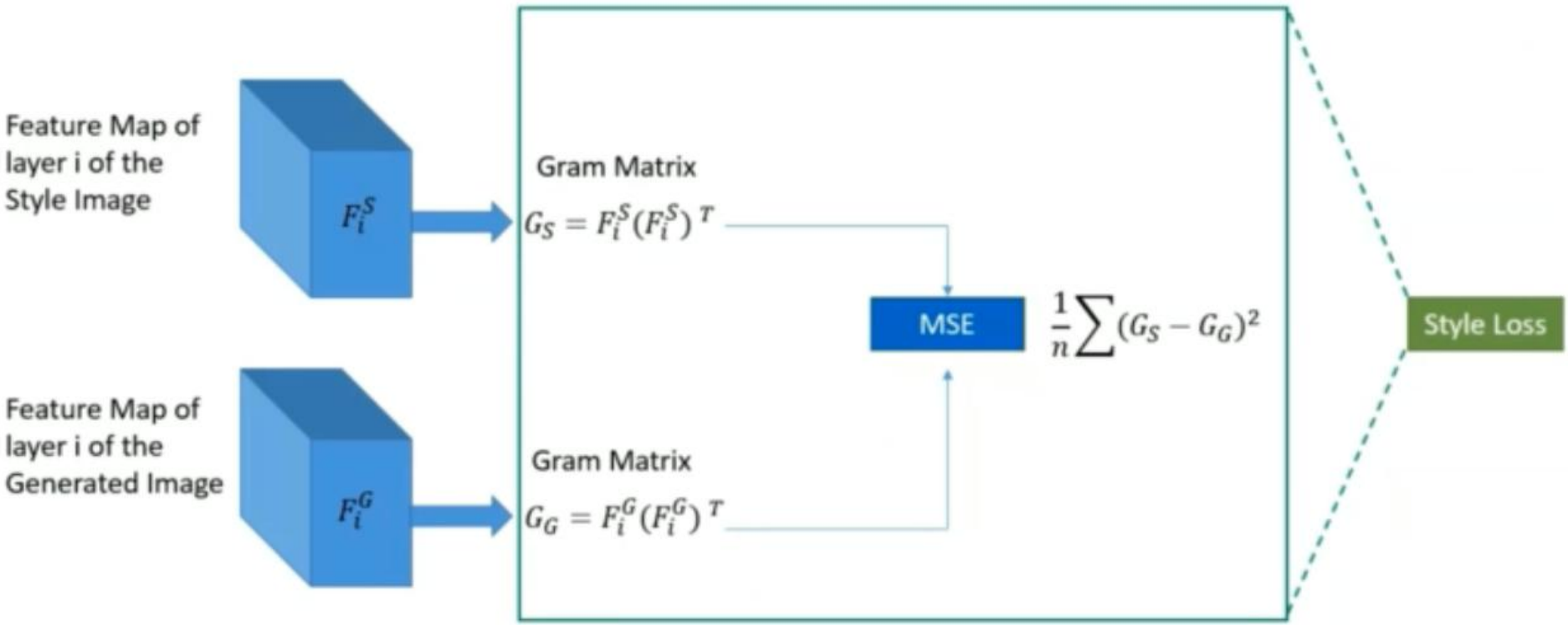
$$r = \frac{\sum_{i=1}^{n} (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \overline{x})^2 \sum_{i=1}^{n} (y_i - \overline{y})^2}}$$

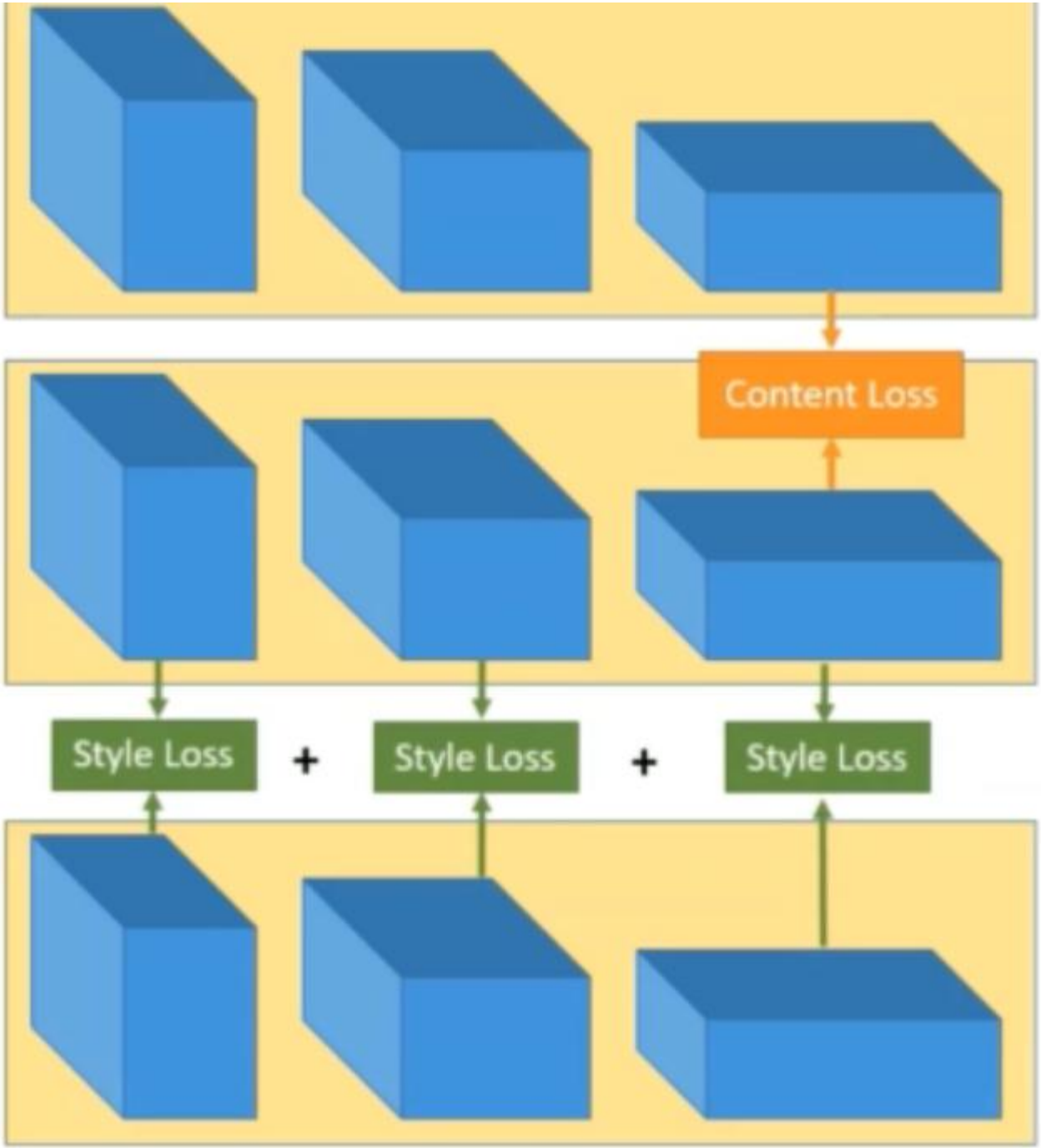
# Gram Metrics

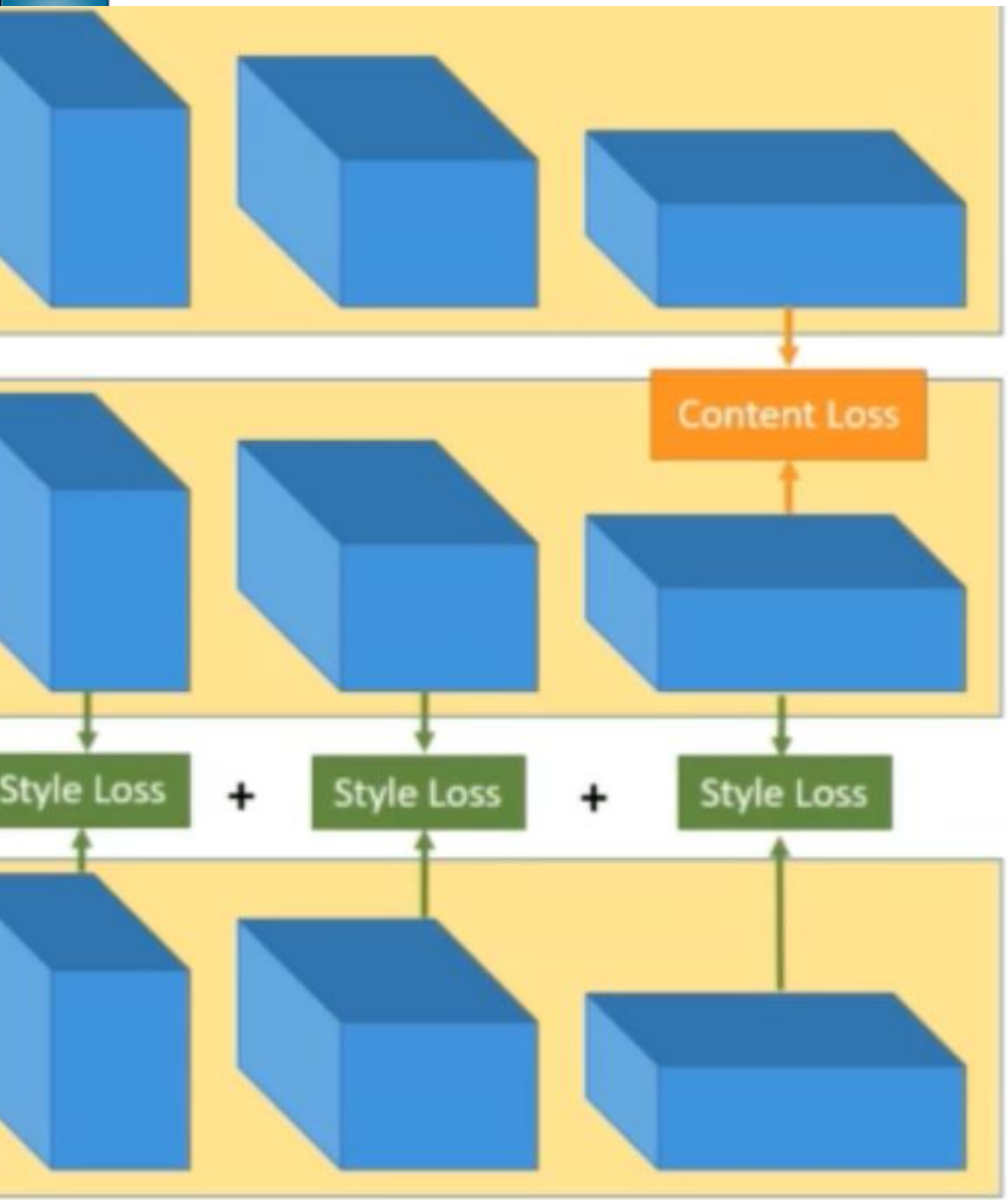
$$G = X^T X$$

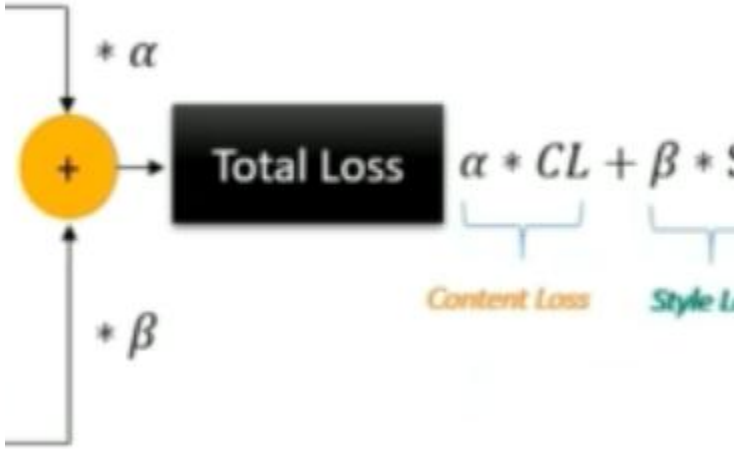
Flatten 3D feature maps into a 2D map

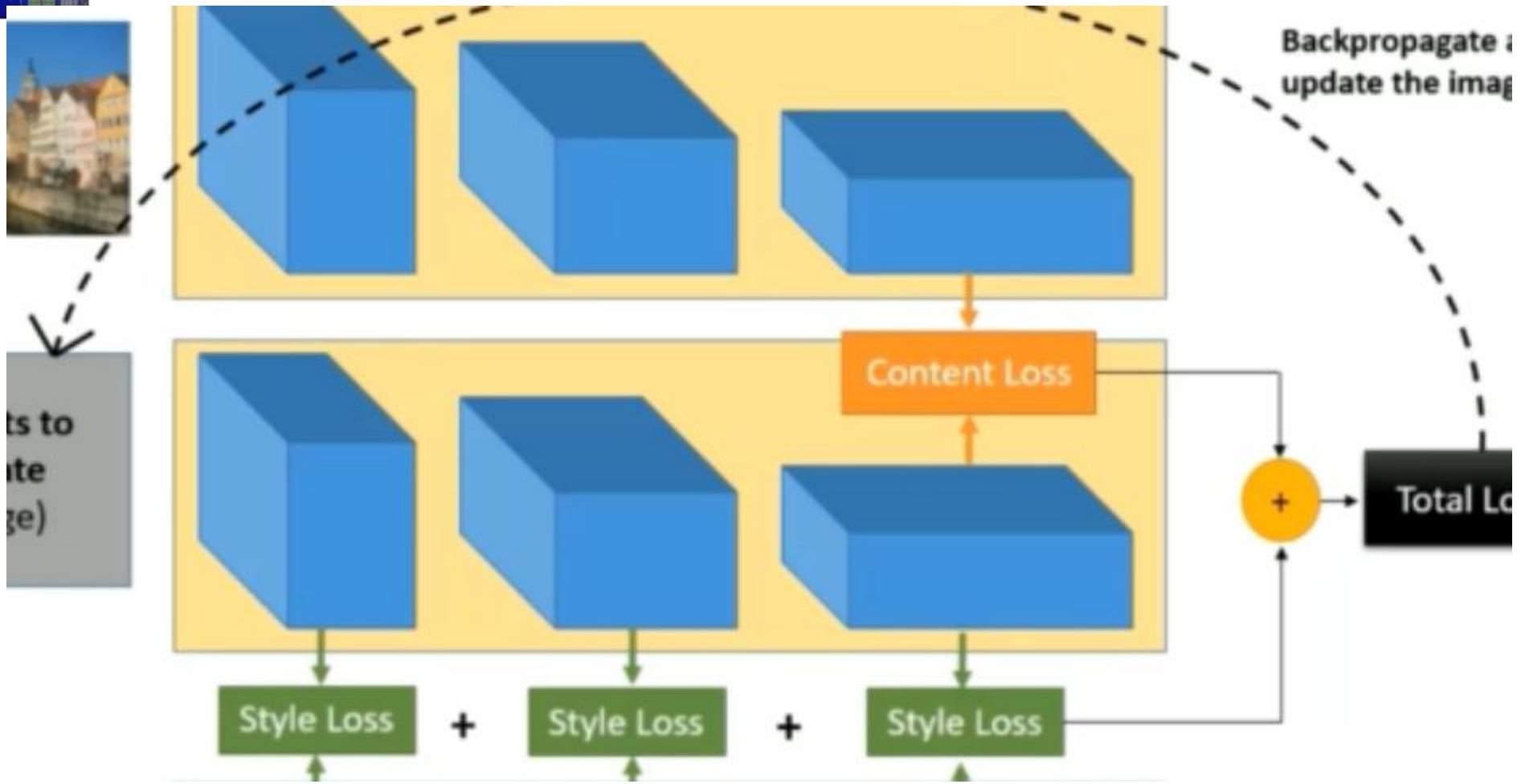
# Style Loss


Feature Map of layer i of the Style Image
$F_i^S$
Gram Matrix
$G_S = F_i^S (F_i^S)^T$
Feature Map of layer i of the Generated Image
$F_i^G$
Gram Matrix
$G_G = F_i^G (F_i^G)^T$
MSE
$\frac{1}{n}\sum (G_S - G_G)^2$
Style Loss


Content Loss
Style Loss
+
Style Loss
+
Style Loss


Content Loss
Style Loss
+
Style Loss
+
Style Loss


* α
+
Total Loss
α * CL + β *
Content Loss
* β


Backpropagate
update the imag
ts to
ite
ge)
Content Loss
+
Total Lo
Style Loss
+
Style Loss
+
Style Loss

# Questions?