# Applications of Art Transformations

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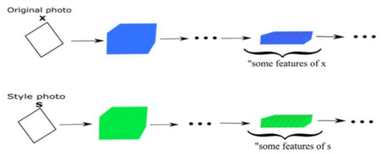
MATH450: Intro to Numerical Analysis I

## Overview

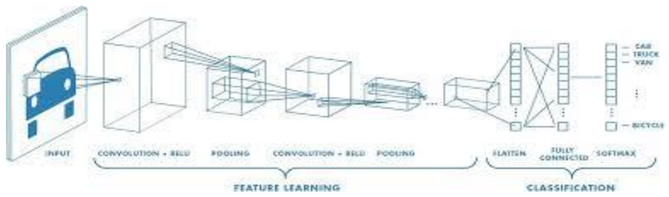
Art transformations are a type of software that applies the visual style of one image to the content of another image using a class of machine learning algorithms known as Deep Convolutional Generative Adversarial Networks (DCGANs).




## Example

## Components of DCGANs

- Unsupervised Learning
  - Finds similarities, dissimilarities, trends, and low-dimensional representations of data.
- Deep Learning
  - Uses multiple layers of 'neural nodes' to progressively extract high level features from data.
- Convolutional Neural Networks
  - Assigns importance to various features in given data and differentiates them.




- Generative Adversarial Networks
  - Trains two networks competing against the other.
  - Generator: Produces new content based off of trends, patterns, and representations.
  - Discriminator: Determines whether sample content is from the data's distribution or the generator's model distribution.

## Numerical Analysis Aspect

- Loss Function & Gradient Descent

  When performing art style transfer, we want to ensure we get an optimal result. This is computed through optimizing for the following functions:

  1. Generator (**G**): max(log(**D**(**G**(n))))
  2. Discriminator (**D**): max(log(**D**(s)))

  where n is a noise variable and s is a sample image.

  We use stochastic gradient descent to minimize these loss functions so with each iteration the total loss becomes lower and lower.

- Complexity

  The complexity of this algorithm:

  $$3 * (m - (j + 1)) * (n - (k + 1)) * (t * u) * i * c$$

  with the variables defined as

  m x n input dimension in pixels
  j x k convolution window dimensions in pixels
  t number of hidden layers in network
  u number of units per layer in network
  i number of iterations to repeat computation
  c complexity of computation

## Other Applications

- Neural Networks are being created and improved upon in order to mimic how neural pathways work in the brain so computers can perform similar, complex tasks as humans.
- The application of Neural Style Transfer can be adapted not only for creating art, but also used to create new, realistic data for data-sparse fields.

  Areas within machine learning, medical research, natural resources, and many others unfortunately only have access to data sets that are biased or lack enough samples.

## Sources

1. "A Neural Algorithm of Artistic Style," Leon A. Gatys, Alexander S. Ecker, Matthias Bethge, Sept 2nd, 2015.
2. "Style Transfer Using Deep Neural Network and PyTorch," Ritul, Dec 17th, 2018
3. "Neural Style Transfer Using Eager Execution", R. Yuan, Google CoLab Notebook, 2018