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edge2art: Edges to Artworks Translation with Conditional Generative Adversarial Networks

Rafael Gallardo-García^{1,2} Beatriz Beltrán-Martínez^{1,2} Carmen Cerón¹
Darnes Vilariño Ayala^{1,2}

Benemérita Universidad Autónoma de Puebla¹, Language & Knowledge Engineering Lab²

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- Introduced by Ian Goodfellow in a paper¹ in 2014.
- Generative Adversarial Networks belong to the set of generative models.
- A generative model is able to produce/generate new content.
- Training is done via an adversarial process.
- GANs are Unsupervised models.

¹Generative Adversarial Networks in arXiv:1406.2661

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A GAN consists in two models trained simultaneously:

- A generative model G captures the distribution of the training data.
- And a discriminative model D that estimates the probability that a sample came from the training data rather than G .
- Both models(networks) are trying to optimize a different and opposite objective or loss function.

The illustrated architecture

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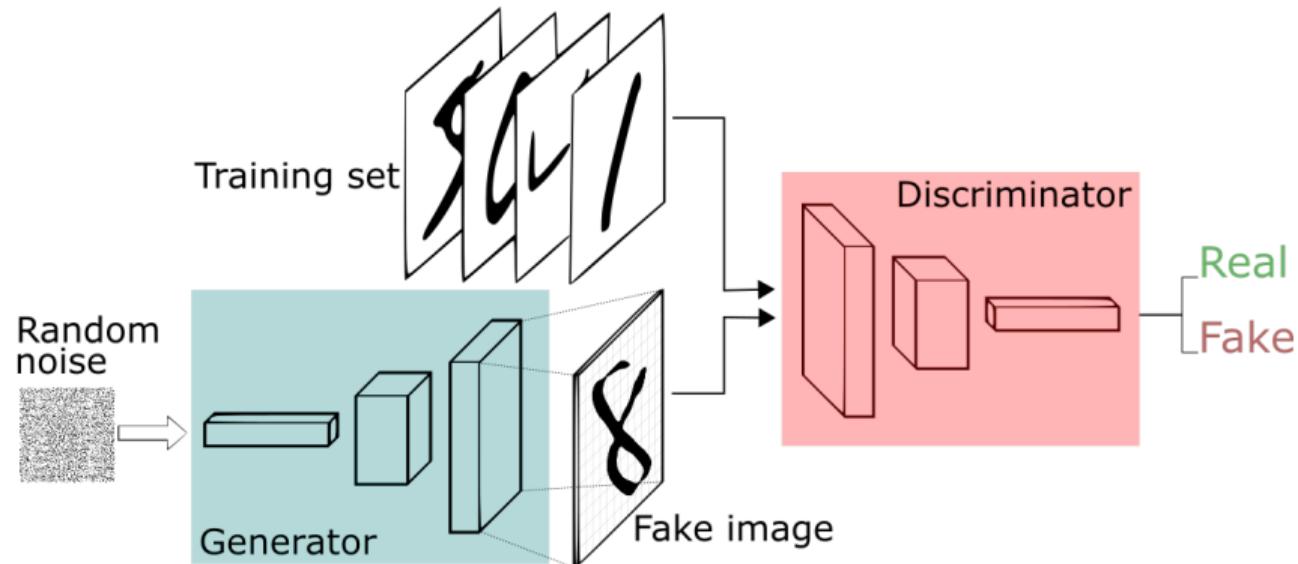


Figure: GAN Architecture

How does the generator work?

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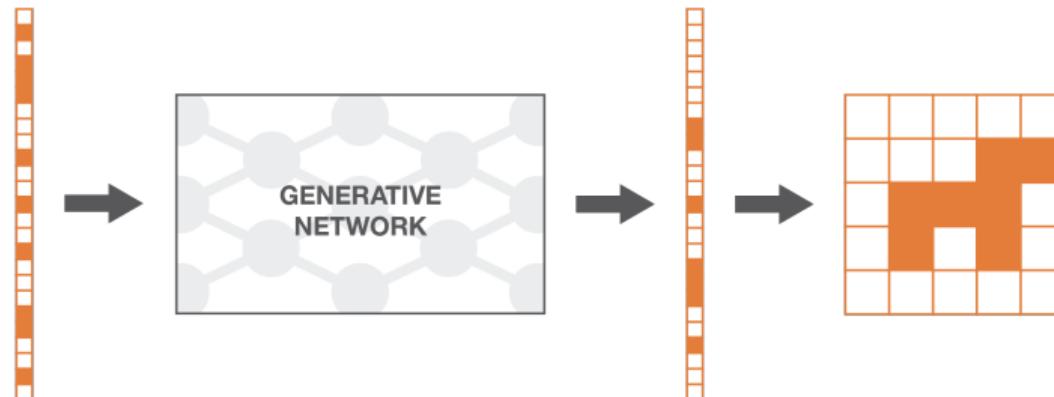
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Input random variable
(drawn from a simple
distribution, for
example uniform).

The generative network
transforms the simple
random variable into
a more complex one.

Output random variable
(should follow the targeted
distribution, after training
the generative network).

The output of the
generative network
once reshaped.

Figure: Illustration of the notion of a generative model.

How the generative network works?

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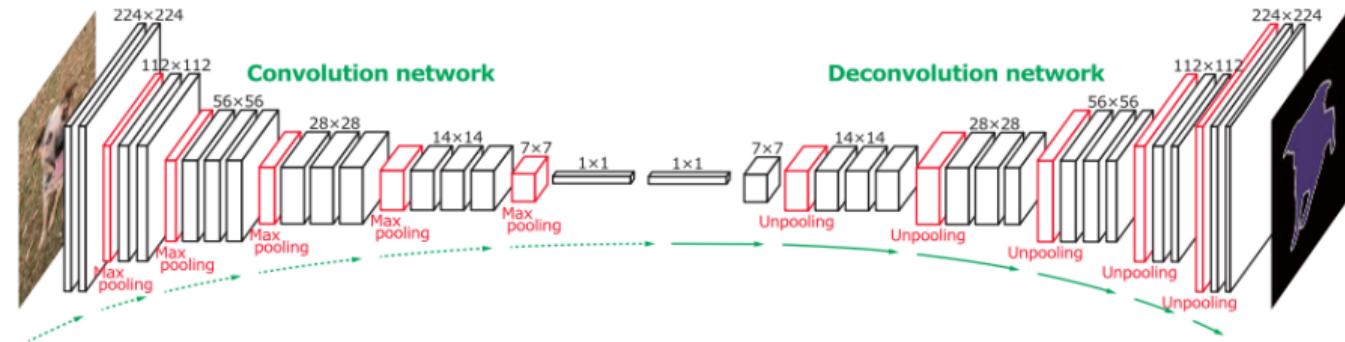


Figure: A Deconvolutional Network for Semantic Segmentation²

Figure 3 shows a Convolutional-Deconvolutional Neural Network with sample-based discretization process.

²Learning Deconvolution Network for Semantic Segmentation in arXiv:1505.04366

What is a cGAN?

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Conditional Generative Adversarial Networks are an extension of the GANs models and share some features.

- cGANs were first proposed by Mirza Mehdi in a paper³ in 2014.
- Has two components: a Generative model G and a Discriminative model D.
- Both are neural networks.
- In cGAN, G and D both receive additional conditioning input information(a vector of features).

³Conditional Generative Adversarial Nets in arXiv:1411.1784

What is a cGAN?

There are one main difference between GANs and cGANs:

- GANs generator outputs depends on the "random noise", which is a vector of random numbers(latent vector).
- cGANs generator outputs depends on the conditioned input vector. Similar to a labeled or supervised training.

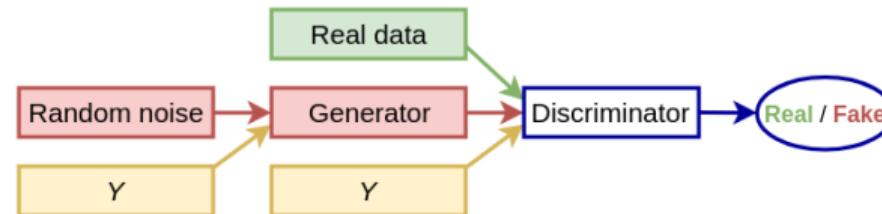


Figure: cGAN Architecture

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Problem

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Any process where an input object has a corresponding output object can be posed as a "translation" problem. This concept is applicable to several problems in image processing where an input image has a corresponding output image.

- A concept in English may be expressed in Spanish too.
- A scene may be rendered as an RGB image, a gradient field, an edge map or a semantic label map.

A good enough solution

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In 2016, Phillip Isola and his team published the paper "Image-to-Image Translation with Conditional Adversarial Networks".

- The paper presents a solution to the image translation problem using cGANs.



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Dataset were obtained from Wikiart⁴. The complete dataset consists in 21 different painting styles and 79,622 artworks.

- Due to the high computational power required to train the cGAN, we select just 3 painting styles, see table 1.

Art Style	# Artwork Examples
Ukiyo-e	1167
Rococo	2089
Fauvism	934

Table: Number of training examples per style

⁴<https://www.wikiart.org/>

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Steps to preprocess the dataset

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- ① Resize every image in dataset to a 256x256px shape.
- ② Extract edges with the Canny Edge Detection Algorithm.
- ③ Concatenate images in order to have both conditional input and target image in the same file.

Some training examples

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Figure: Training examples: Ukiyo-e, Rococo and Fauvism, respectively.

cGAN for Image to Image Translation

Figure 6 illustrates a high-level architecture of edge2art.

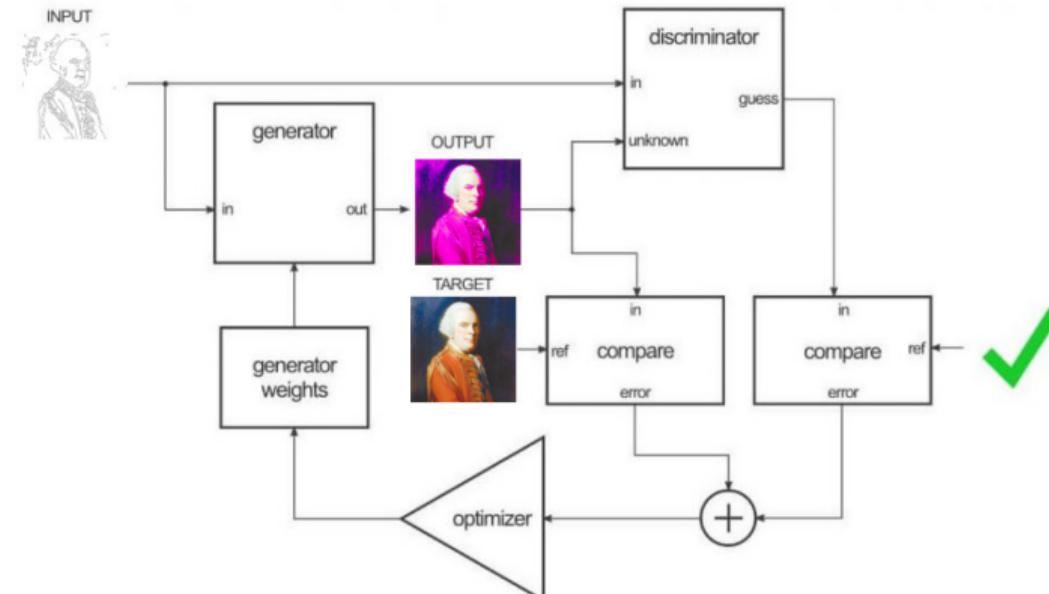


Figure: cGAN architecture of edge2art.



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Output examples: Rococo

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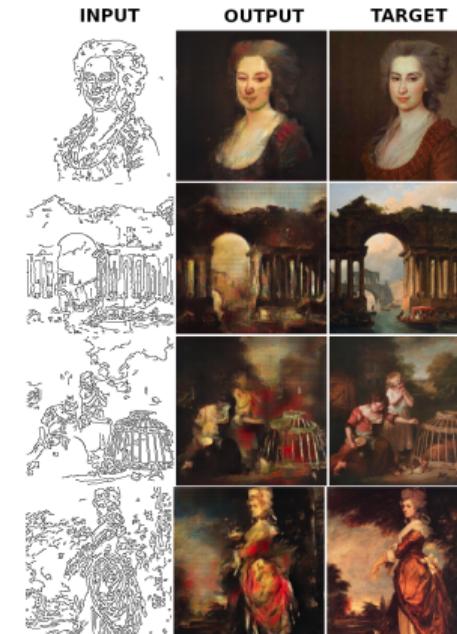


Figure: Edge to Artwork translation examples for Rococo style.

Output examples: Ukiyo-e

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Figure: Edge to Artwork translation examples for Ukiyo-e style.

Output examples: Fauvism

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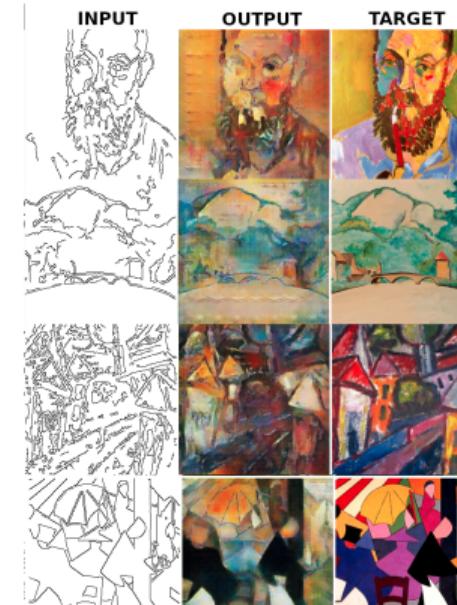


Figure: Edge to Artwork translation examples for Fauvism style.

Problem 2: How to measure similarity between images?

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- There are several methods to measure similarity between images.
- Some are more complex to implement, than others.
- For this paper, we selected the Mean Squared Error and the Structural Similarity Index Measure.

MSE Score

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Mean Squared Error measures the average of the squares of the errors: that is, the average squared difference between an estimated value(edge2art output) and the actual value(target artwork). A 0 score means two completely similar images and higher values means more different images.

edge2art got an MSE score of 20,006 units.

SSIM Score

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Structural Similarity Index is a method for predicting the perceived quality between digital images or pictures. It quantifies image quality degradation caused by processing. SSIM is almost used for measuring the similarity between two images. edge2art got an SSIM average score of 0.10766, where -1 is completely different and 1 is completely similar.



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- Clearly, the obtained scores are not good enough to consider the experiment as a success in MSE and SSIM.
- MSE and SSIM evaluate the similarity between the images by comparing the information of the pixels and not by evaluating the content or the context of the images.
- edge2art scores could be improved if the measuring methods are improved too.

Conclusions and Future Work

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- Future work contemplates new measuring methods for edge2art.
- Future evaluations includes content analysis and classification methods for images with feature extraction techniques.
- Proposed feature extraction techniques: SIFT(Scale-Invariant Feature Transform) or HoG(Histogram of Oriented Gradients).
- In order to measure similarity with a content approach.