Analyzing the implications of GANs in AI Art through GANGogh, and Similarity Scoring

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***Abstract*— This project aims to explore the creative implications of GANs in the emerging AI art industry. As AI art becomes more prevalent, we wish to investigate how close AI art can approximate a specific artist's style. To do so, we will use the GANGogh basis to attempt to teach a GAN to generate images of art that mimic Vincent Van Gogh's style, which falls into the artistic periods of Impressionism, Post-Impressionism, and Neo-Impressionism, to see how well the GAN can create images that could be considered Van Gogh's work if he was still creating art. We also wish to analyze the ease and effectiveness of the GANGogh project, which is currently very popular in the ARTGAN industry.**

Keywords – ARTGAN, GANGogh, AI Art

Background

Before we discuss the methodology for creating a GAN to simulate Van Gogh's work, it is important to understand the artistic movements that Van Gogh operated in, as well as the characteristics of his work. We will then discuss GAN's and how they work before describing related work.

I. Impressionism

Impressionist art was well known during the 1870s and 1880s but harshly criticized by the artistic establishment within France. It was characterized by an emphasis on semi-realistic portrayals of outdoor real-life scenes with small, and thin brush strokes. Interestingly enough, it proved a great medium to implement depictions of light and movement. This lead to the rise of grand forms of art that included large ships, bustling crowds, and busy streets [1].

As listed below, many great works were created during this time including "Dance at le Moulin de la Galette" (1), "Impression, Sunrise" (2), and the early form of "The Fighting Temeraire" (3) [2].

II. Examples of Impressionist Work

(1)

(2)

(3)

III. Post-Impressionism

Post-impressionist art was, to a degree, a rebellion against the strict rules and otherwise plain creative freedom of Impressionism. Starting in 1886 and ending in 1905, many famous Impressionist painters took it upon themselves to embrace the freedom of post-impressionist work.

While it certainly gets its roots from Impressionist paintings including vivid colors, and real-life emphasis, there was significantly more personal touch including detail-less geometric shapes, distorted forms, and strange and unnatural colors [3]. This wide breadth of art led to drastically different works from the famous "A Sunday on La Grande Jette" (4), to the grand "Montmartre, de la rue Cortat, vue vers saint-denis" (5), to the strange "Interieur aux deux verres" (6).

IV. Examples of Post-Impressionist Work

(4)

(5)

(6)

V. Neo-Impressionism

Neo-impressionism was a form of art style that lasted between 1884-1886 that is widely considered a subset of the broader post-impressionist movement. In fact, one of the most famous post-impressionist artworks, the "A Sunday on La Grande Jette", is technically considered a neo-impressionist painting.

The art style was born of an interest in combining optics science and changing societal patterns. Rather than wide sweeps and strokes or palette-based mixtures, artists attempted to place micro dots of dye onto the canvas and permit the observer to see the broader image themselves. Many artists systematically contrasted colors and tones to create unique effects in a broader bid to paint modern life [4]. This time period saw many great works including Vincent van Gogh's "Self-Portrait with Felt Hat" (7), "The Evening Air" (8), and "La Dame a la Robe Blanche" (9).

VI. Examples of Neo-Impressionist Work

(7)

(8)

(9)

VII. Vincent Van Gogh

Vincent van Gogh was a classic example of a misunderstood genius ahead of his time who operated in the aforementioned artistic periods. Within just a decade, from 1883 until his suicide in 1890, he created a significant number of pieces that drew significant objections and insults including the title of madman [5].

He initially painted within the confines of impressionist art within deeply dull and sad contexts including poor peasant farmers. It was not until he moved to Arles that he began to embrace post-impressionist work and began utilizing his characteristic vivid colors. In fact, his style embraced the use of colors to capture his desired mood as opposed to realism.

He often utilized his strong but relatively short brushstrokes in conjunction with his improved, yet strict palette to express his emotional response. He therefore demonstrated perhaps one of the strongest anti-impressionist mentalities with his demand to push his interpretation and opinions onto his works [6]. This is greatly evident in his incredibly famous paintings including the solemn "Starry Night" (10), his single-minded "Sunflowers" (11), and his numerous self-portraits such as the aptly named "Self-Portrait" (12).

(10)

(11)

(12)

VIII. Generative Adversarial Networks (GANs)

Generative adversarial networks (GANs) are a family of algorithms that use two neural networks working against each other in order to generate new, synthetic instances of data that can pass for real data. They are used widely in image generation, video generation and voice generation, which is why a GAN is strongly suited for our task at hand. GANs are also the underlying architecture in DeepFakes, which is why it is especially important for us to use a GAN as the generative structure to later test how accurate the new images are.

We will use a GAN based on the GANGogh project (https://github.com/rkjones4/GANGogh), as this is currently the leading basis on generating art based on an artist's work. Our mission is two-fold: we want to recreate the GANGogh results to test its ease of use, and we want to understand the similarity between our results, GANGogh's results, and Van Gogh's actual work.

IX. Related Work

Previously, researchers have explored how artificial intelligence can be used to aid artists, which raised further research questions on what is considered art. AICAN [7] was one of the first popular AI processes for creating art. In Aaron Hertzmann's paper [8], the idea of whether computers can be considered artists is explored, as well as whether the person who created the algorithm or the computer is considered the artist of the generated art. In October 2018, Christie's in New York auctioned an artwork created by a GAN, demonstrating the increasing prevalence of the field [9]. Currently, scams such as DeepFakes can take away a person's autonomy, so this paper will consider the dangers of AI art in an artist's autonomy of style.

Datasets

In our work, we use two main datasets to accomplish the two objectives of this project. The first is used to emulate the GANGogh model, and the second is used for similarity scoring.

I. Wiki-Art Dataset

The first dataset is training data taken from wikiart.org. The original GANGogh was trained in this, so we wanted to emulate the original model to the best of our ability. It can be found here: https://drive.google.com/file/d/1yHqS2zXgCiI9LO4gN-X5W18QYXC5bbQS/view. This dataset was originally created by scraping over 80,000 images from wikiart.org while maintaining the style labels and genre labels. Included in this section are samples from the animal, flower, marina, and mythology categories.

A. Animal Samples

B. Flower Samples

C. Marina Samples

D. Mythology Samples

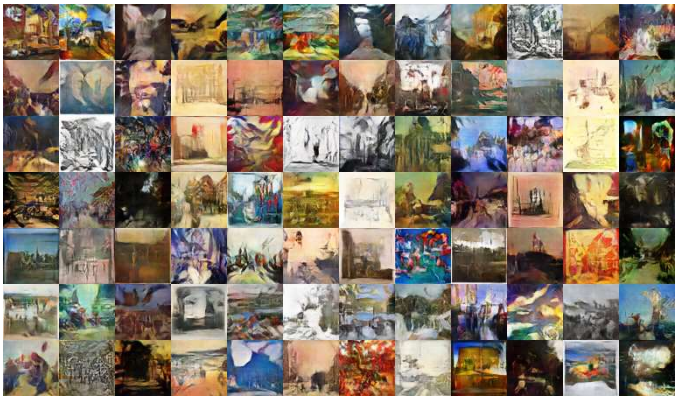
II. Output Images Dataset

The second dataset we used was the output images from the original GANGogh. This dataset consists of 84 64 by 64-pixel images per genre. The genres were abstract, animal, cityscape, figurative, flower, genre, landscapes, marina, mythology, nude, portrait, religion, still-life, and symbolic. We built this dataset by taking the overarching images for each genre created by the original GANGogh, which were 768x448 pixels, and splitting them into 64 x 64 images. Included in this paper are examples of original images for a subset of these genres.

A. Abstract Outputs

B. Animal Outputs

C. CityScape Outputs



D. Flower outputs

E. Marina Outputs

F. Mythology Outputs

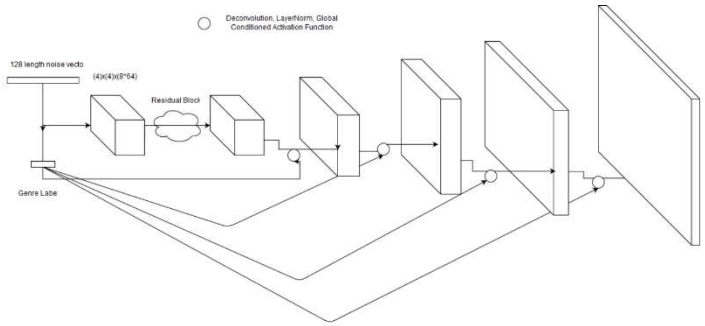
G. Still Life Outputs

GANGogh Model

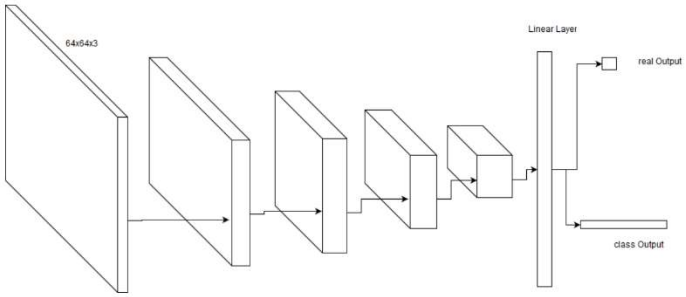
GANGogh is built off the Wasserstein model in extension of the AC-GAN framework. The generator and discriminator are set up under the Wasserstein model, but also a component was added for the discriminator to identify different genres. The generator would have an additional input for a one-hot vector to define what type of painting it should produce.

Additionally, the discriminator is pre-trained to identify different genres, so that once the generator starts training, it learns how to build different genres of images.

A. Generator Model



B. Discriminator Model



Similarity Scoring

We randomly selected combinations of 10,000 generated images * 10 ground truth images to calculate overall similarity of the generated data to the original data. We used a standard 2-norm to find the relative difference, as such:

$$\frac{\|generated - ground\_truth\|}{\|ground\_truth\|}$$

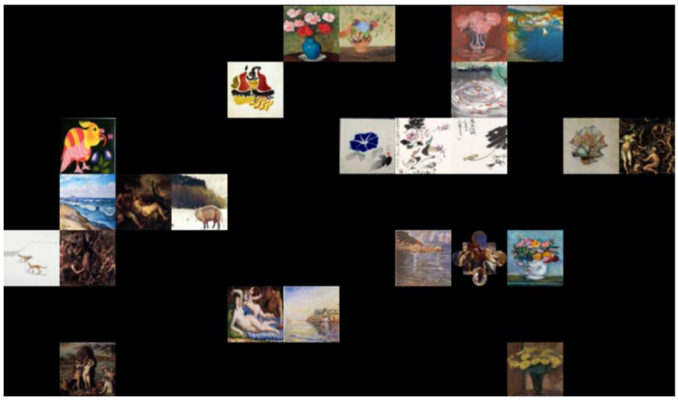
and used that as a difference score. We also saved the pair of generated image and ground truth image that had the least difference, as well as the mean, for 3 different genres: Animal, Mythology, and Flowers.

Results

I. Implementing GANGogh

Using the code given in the GANGogh repo, we attempted to recreate the model to see what the results looked like and judge its ease of use and quality. When we tried to use the code out of the box, there were issues with compatibility, and many of the items were hard-coded. The repository also has not been maintained in the last two years, so many hardcoded links no longer point to the right locations. As a result, we had many issues getting the correct dataset, and once we fixed the majority of the issues, our dataset was not as complete as the original dataset used by the GANGogh author.

II. Outputs



Initial Ground Truth Image

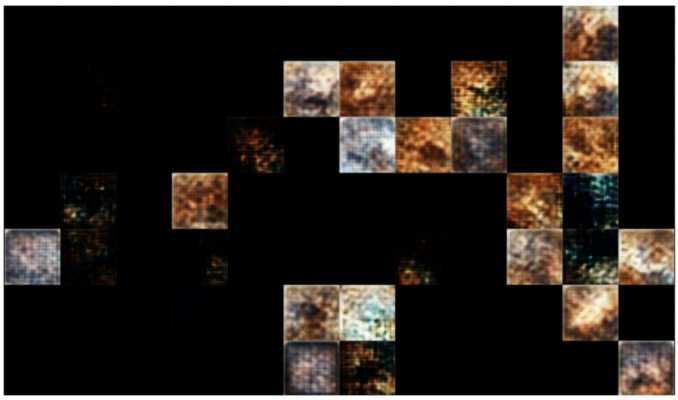


Image after 9 Iterations

GANGogh Final Output with Limited Data

Unlike the expected output listed on the GANGogh documentation, our output was missing a lot of the expected detail. We suspect that this is due to the missing data in our set.

III. GANGogh Analysis

We will judge GANGogh on the following categories: ease of use, dataset quality, and code quality.

A. Ease of Use

Using the GANGogh model was relatively straightforward except for technical issues with compatibility between different versions of tensorflow, and some pieces of the code that war hardcoded and created bugs.

B. Dataset Quality

The dataset was originally of high quality and good volume, but unfortunately, we were not able to successfully unzip it, as the file was too big and became corrupted. We trained on what we had.

C. Code Quality

As mentioned previously, besides the issues with compatibility and hardcoding, the code was relatively easy to understand and modify to our needs.

D. Final Thoughts

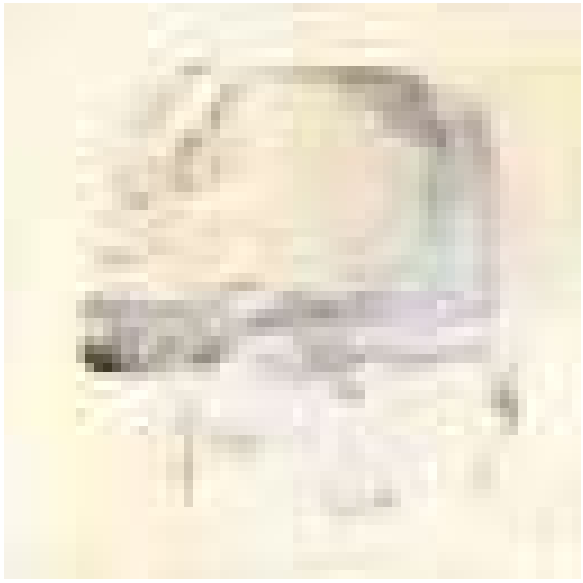
Overall, it is evident that although the original GANGogh claims to have clear results, it is not easily replicable. Furthermore, looking at the original GANGogh results, the output images are very similar for each genre, which makes it more unclear on how effective the model actually was.

IV. Similarity Scoring on the Original GANGogh Outputs

The similarity scoring used the outputs generated by the original authors of GANGogh, rather than our outputs. For each of the three genres we analyzed, we will present the original seed image, the best generated image, the minimum difference, and the average difference.

A. Animals

Original Seed



Best Generated Image

For the animal category, the minimum difference was 0.6002136665310018, and the average distance was 1.2552456717792042.

B. Flowers

Original Seed

Best Generated Image

For the flower genre, the minimum difference was 0.5250998042651865 and the average difference was 1.1528293636458058.

C. Mythological

Original Seed

Best Generated Image

For the mythological category, the minimum difference was 0.7850676886499843, and the average difference was 1.3734476549619818.

Conclusion and Further Questions

Moving forward, we would like to further analyze the psychological ramifications of what it means to be an artist. As AI art becomes more prevalent, we would like to investigate if it is possible to create a model that can discriminate between art created by humans versus art created by an AI. We would also be interested in seeing how improvements can be added to GANGogh to make the model more robust and streamlined for future use. Lastly, we'd like to take our similarity scoring metrics and make them more robust for application to DeepFakes. This way, we can create better detection algorithms for those whose work was copied.

Our code:

https://colab.research.google.com/drive/1Zsmn9lijT0sMgkAyLFUUFSuqdLO70Mc1

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