AINA

AI and Analytics

Volume 2 • Edition 2020-21

COVER STORY

ART IS MATH

Annual Analytics Magazine from the Students of PGDBA

Post Graduate Diploma in Business Analytics : Jointly offered by IIM Calcutta, ISI Kolkata & IIT Kharagpur

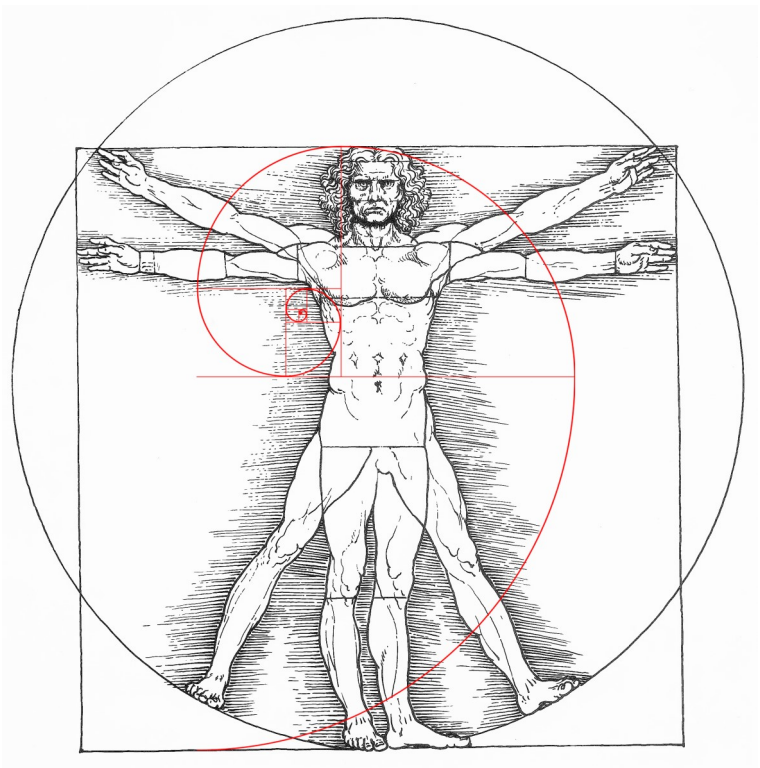
Art is Math

Raj Chauhan

Memes questioning the use of math in real life are well-liked, and while I did understand that they were nothing more than harmless jokes poking fun at math, I would always be on the lookout for numbers in real life to verify if there was any truth to those memes. While reading the ever-popular 'The Da Vinci code', we all stumbled upon the influence of math on a not so glaringly obvious subject – Art.

And not just influence it, math through AI is now creating art.

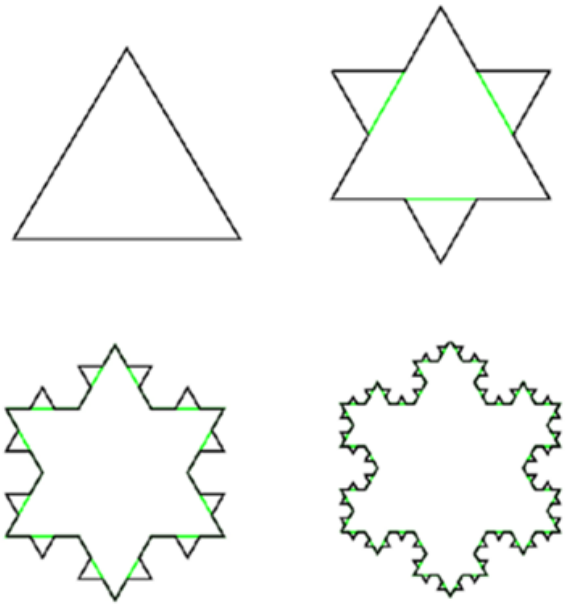
Math in Art



By observing patterns in nature, we identified the mathematics behind them to understand what catches our attention. The golden ratio (phi or 1.618) occurs in nature in several patterns, and artists used this ratio in their works, from Leonardo da Vinci to the builders of the great pyramids of Giza.

The golden ratio known as the divine proportion during the renaissance appeared in several Da Vinci works. He also created illustrations for the book De Divina Proportions by Luca Paoli.

A 2021 research study by the University of Oregon claimed that babies by age 3 prefer fractal patterns found in nature. Fractals are complex repetitive patterns that maintain a spatial symmetry at all scales.



Children up to this age live in structures devoid of these fractal patterns. Their houses employ straight lines in their architecture. The study suggests that the human brain may have evolved to consider fractals as pleasing to the eye and not something it learns to admire.

An example, the Koch Snowflake is a fractal curve created by repetitions of equilateral triangles. It is developed by Helge von Koch.

Mathematics is prevalent in art and aesthetics. Can we use mathematics to enhance art?

Engineering Aesthetics

Today people spend a lot of time staring at screens. User Interface or UI designers follow a few mathematical rules while designing an app or any webpage; to compose interface elements design for users to perceive the information efficiently. The golden ratio also appears in UI design to create rectangular design elements and font size selection. To select two different font sizes: for a heading and a subheading, designers first fix one of the two according to visibility requirements. For a bigger font, the other font size is multiplied by 1.618, and for a smaller font, it is divided by 1.618.

The rule of thirds is another practice that enhances designs. Four lines divide the digital canvas into three equal-width horizontal and vertical segments. Designers place the most impactful elements along these lines or their intersections.

Creative use of aesthetics can enhance even everyday PowerPoint presentations. One such application is colour palette generation. An average analyst has limited design experience and uses application suggested colours or presets to make his presentations. Automatic colour palette generators help these users to choose from a seemingly infinite variety of colour palettes without being an expert in creative disciplines.

The online generators are programmed to bundle colours that look good together. A few of these are AI-powered generators trained with datasets of images of photographs, modern art and movies. A few of these are AI-powered generators trained with datasets of images of photographs, art and movies. Mathematics, and now AI provide good design practice guidelines to enhance the user experience. But we can use design to enhance the presentation of mathematics too.

Visualising Mathematics

Data visualisation or infographics make it easier for a user to understand statistical or quantitative results in a report. Generic visualisations of the data achieve the objective of explaining the data but a well-designed and planned presentation results in more attention paid to the reports.

Several companies have now identified the need of having a structured design approach. They have formulated detailed guidelines on designing their infographics. These guidelines include having their colour palettes to maintain uniformity over the designs of presentations and brochures. Design principles, like the use of whitespace, and layout styling, helps companies to publish visually pleasing reports.

Apart from aesthetics, art is a medium for conveying a message from the artist to the audience. The artist is a storyteller through his/her art. Storytelling is also an aspect of data visualisation. Every effective visualisation must contribute to the explainability of the problem highlighted by the report, rather than simply acting as a graph in it.

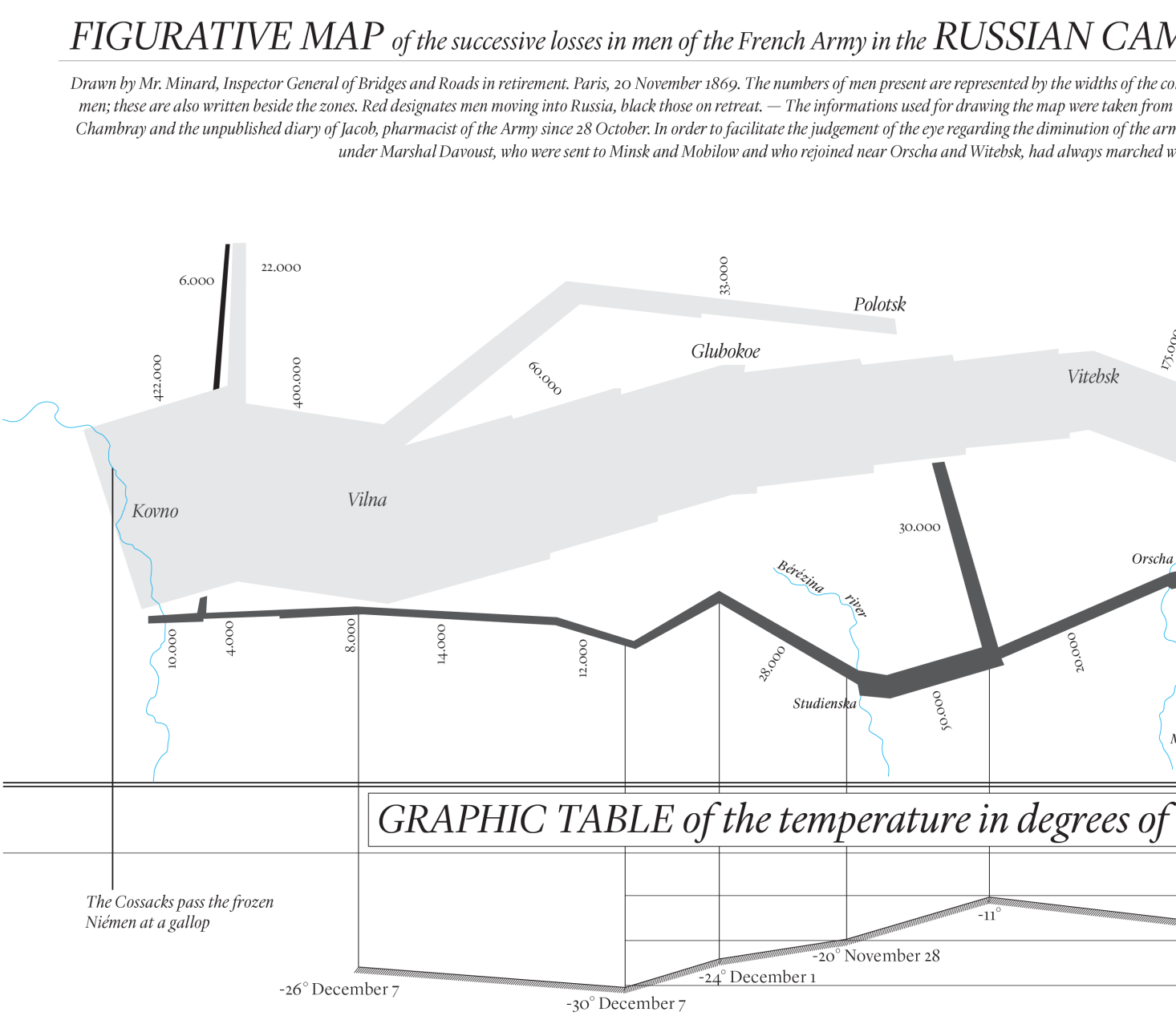
The infographic by Charles Minard on the invasion and retreat of Russia by the French army led by Napoleon (flip page to view the infographic) is a masterpiece in storytelling through an infographic.

In his book ‘The Visual Display of Quantitative Information’, Edward Tufte called the infographic the best statistical graph to have ever been produced.

At first glance, the infographic appears to be two line graphs with varying width. When the significance of this width dawns on the user, the infographic transcends into a work of brilliance...

The greatest infographic

Napoleon's march of Russia by Charles Minard



Legend

French army moving into Russia

Retreating French army

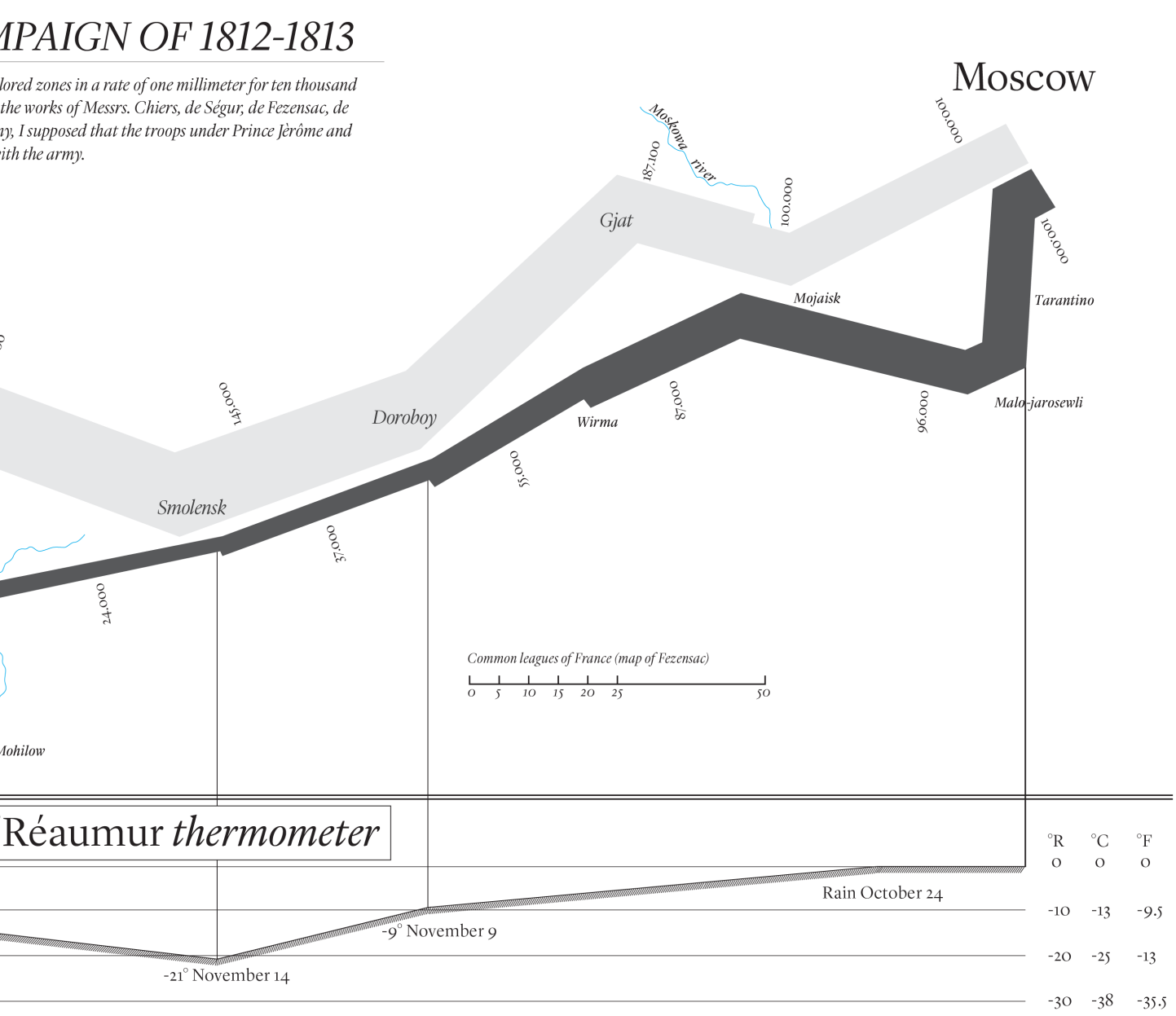
width

Number of soldiers

When Napoleon's French army begun its campaign to Russia with 475,000 men, the Russian army of about 200,000 men stood no chance of a victory. Russia employed an attrition warfare of scorched earth policy leaving Napoleon to rely on his supplies which was incapable of supporting his large army.

By the time the French reached Moscow, their numbers had dwindled to just a 100,000 men owing to lack of supplies, the harsh Russian weather, and two battles.

Napoleon had reached Moscow victorious in his battles, but the Russians left Moscow, burning it down while retreating. Napoleon could not keep up his supplies and



had to begin his retreat as Russian winter was setting in. The temperatures are displayed in the chart below the army movement graph.

By the time they retreated back to France, only 10,000 of the original 475,000 soldiers survived.

Our mind often finds it difficult to interpret large numbers. The infographic, by using the width of the lines for army strength, tries to overcome this difficulty and portray the true nature of this campaign.

The infographic displays 6 variables:

- The size of the army
- The direction of movement
- The relative location of places during the campaign
- Temperature
- The dates of the campaign.

With the amount of information conveyed, Edward Tufte was correct to call it '*the best statistical graph ever drawn*'

AI as an artist

In 2017, the auction house Christie's auctioned Salvator Mundi by Leonardo da Vinci for $450.3 million at their New York premises, making it the most expensive painting. Garnering equal discussion the very next year, Christie's at their London premises sold a portrait of a man named Edmond de Belamy for $432,000.

Edmond de Belamy is a fictional persona and the work of Artificial Intelligence. The signature on the painting is a mathematical formula: the loss function used to create the artwork. A French group called Obvious, who study interactions of art and AI, used Generative Adversarial Networks or GANs to create the portrait. They trained the network with 15000 renaissance portraits for the GAN to create the artwork.

How do GANs create art?

A GAN architecture consists of two parts: a generator and a discriminator. The generator is fed with random data or noise and generates an image. This image is then looked at by the discriminator, which uses the training dataset given to it to classify whether the generated image looks like the dataset or not. It discriminates the true art (in the training dataset) from the fake art (from the generator).

The generator then takes this as a feedback and tries to create a better fake image to confuse the discriminator. It treats the discriminator as an adversary which it has to fool. The network training is a min-max game: the generator tries to maximise the discriminator loss. The discriminator tries to minimise it.

The result is an equilibrium where the discriminator can no longer identify fake images given by the generator. As the discriminator cannot distinguish the GAN made art from the training set provided, it retains the art style of the training dataset and does not create its art style.

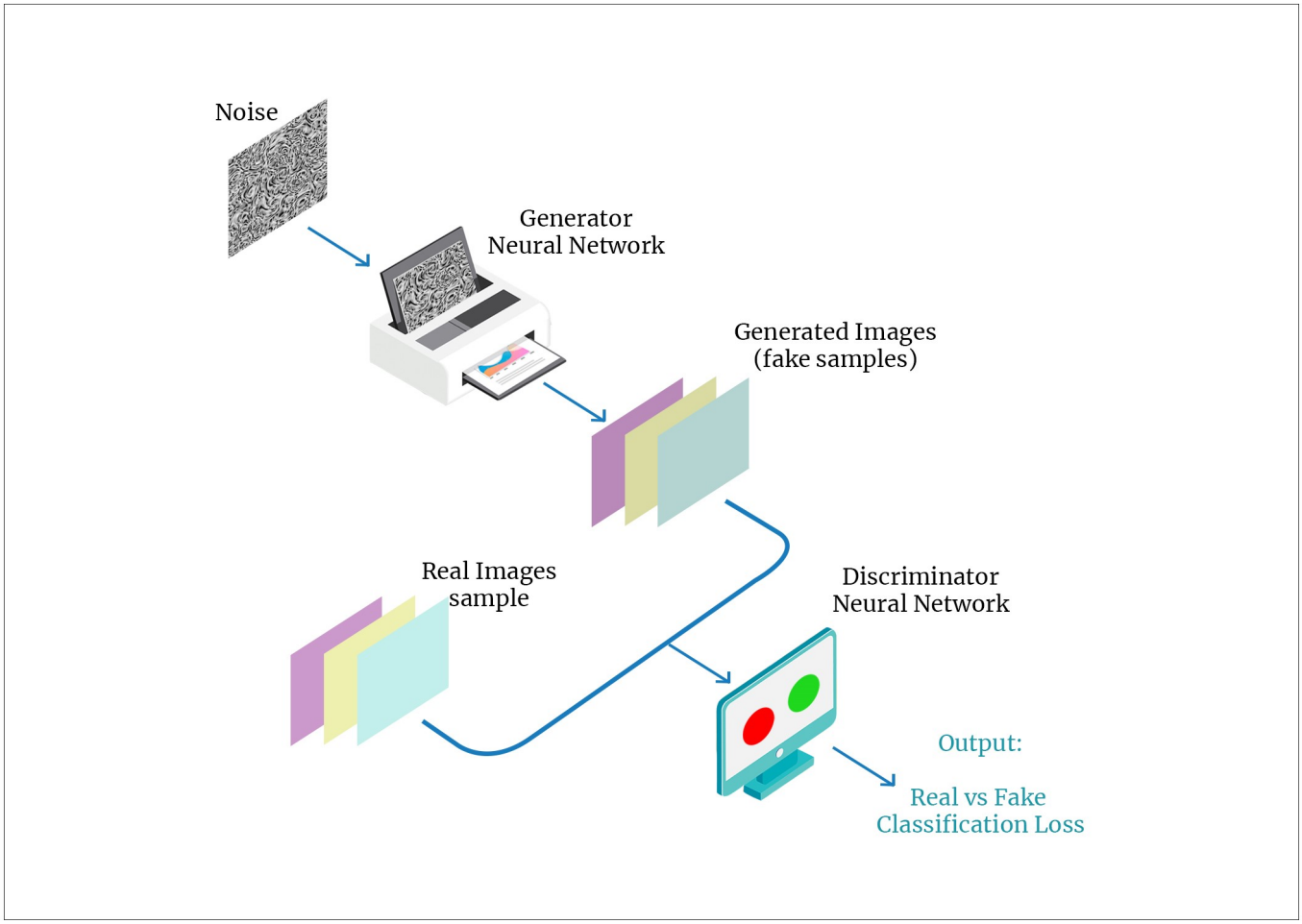
Ahmad Elgammal, a Rutgers University computer science professor, calls GAN made artwork simply repainting. GANs, while trying to mimic an art style, lose the essence of creativity that humans possess.

Elgammal, along with his fellow researchers at Rutgers University AI and Art gallery, came up with an improved architecture for AI-based art, Creative Adversarial Networks or AICAN.

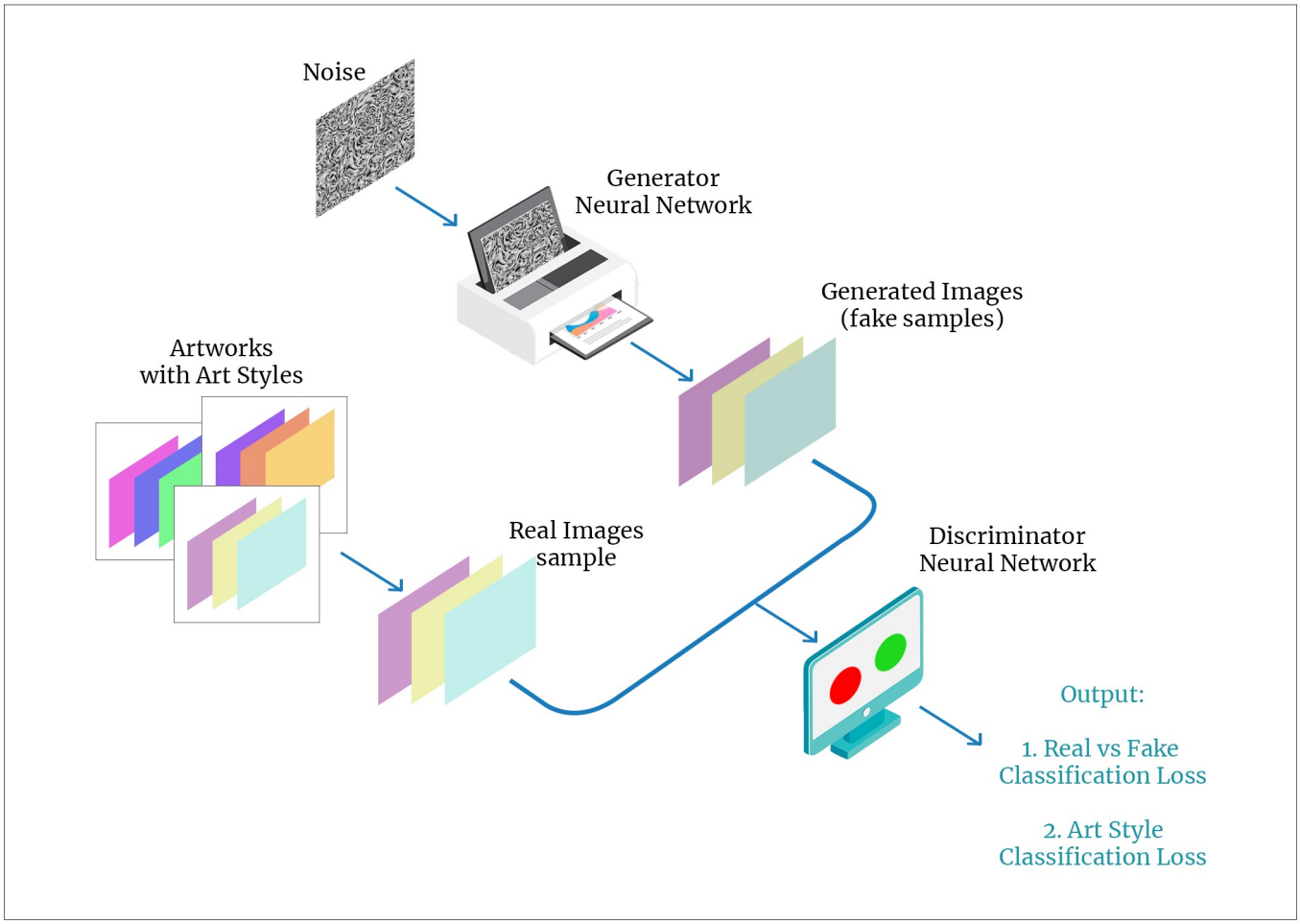
The AICAN, like GAN architecture, involves the generator and the discriminator. But the discriminator in AICAN improves on GAN by providing more feedback. A dataset involving artworks of more than one art style is the training input to the discriminator. When the discriminator receives the generated image, it not only tells the generator whether the image is true art or not, but it also classifies the art style. The generator tries to maximise two losses of the discriminator:

1. Loss of classifying whether the image is true art or fake art, and
2. Loss of classifying art style of the image.

The AICAN successfully confuses the discriminator, to create an artwork classified as true art like the training distribution yet having a unique art style unlike the styles in the training dataset. Essentially, AICAN creates a new art style that looks as real as if humans painted it.



GAN Architecture



AICAN Architecture

Can AI replace human creativity?

In his 2019 paper 'Can Computers Create Art', Aaron Hertzmann of Adobe Research argues that AI and other computer algorithms are mere tools for artists to use. Even if AIs create new art styles, these AIs have to be trained by humans to generate these styles.

Memo Akten is a London based artist and creator of GHCQ - a painting developed using Google Deepdream generator. He calls Deepdream to be just a better paintbrush developed by google and that the human artist is essential. Not just any image given to the computer algorithm can produce artwork that rivals artists, but human interference in this generation process can produce masterpieces, as Akten himself has shown. Aaron Hertzmann believes: Computers do not create art. The people using computers do. Art is a social practice; artists use their works to express their thoughts and interact with their audience.

While currently, the several variations and ideas in an artist's mind remain confined within their realm of imagination, AI generators can enable these potential variations to take a physical form on a digital screen, thereby providing the artists with a gallery of exhibits of their creativity.

Some believe that such a tool undermines the human touch behind

The ceiling of Sistine Chapel, where Michelangelo painted 'Creation of Adam'

creativity, but art has undergone massive technology-assisted developments throughout its history. Be it the use of colours from looking for sources to extract them from nature to now synthesizing even their tints and shades; from using the material available to now selecting the best suitable material for the artwork. Technological developments have helped artists better express themselves, and AI is one such technological development for artists to use.

When you look at 'The Creation of Adam' by Michelangelo, you do not just see Michelangelo's art style but notice that the shape behind God in the painting resembles a human brain. One of its interpretations is how human sentience is the medium through which God in the artwork connects to Adam – humans. Computer algorithms fail to create this contextual subtext without the intervention of artists.

This sentient creativity separates current AI art and artists. But, a partnership of AI systems and human artists can spark a new direction of co-creativity, where technology learns as an apprentice of these top artists. But with the rapid pace of advancements in AI, the question will forever loom if the apprentice can one day become the master.