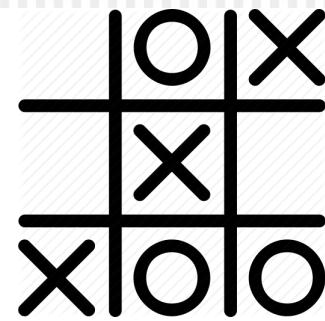
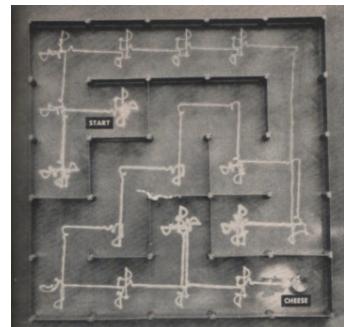
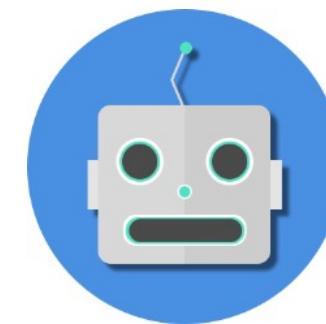
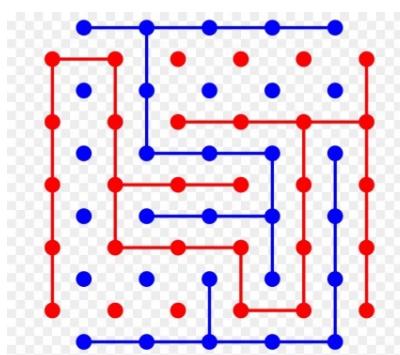
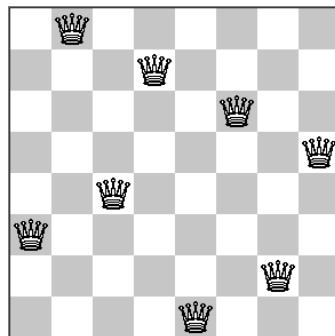


Artificial Intelligence:

Past, Present and Future



Chee Wei Tan

Computational Creativity

- **Computational Creativity:** multidisciplinary endeavor at the intersection of the fields of *computer science, cognitive psychology, philosophy, humanities* and *art*
- AARON (<http://aaronshome.com>) is a computer program written by Harold Cohen to generate original artistic images starting in 1970s
- What makes an image evocative? Can algorithms produce evocative images?



Harold Cohen (1928–2016)

Computational Creativity

It's taken me 20 years to teach AARON to draw. How can I possibly teach it to color before I die?

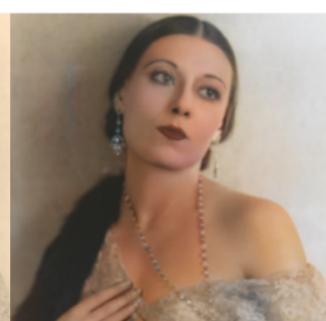
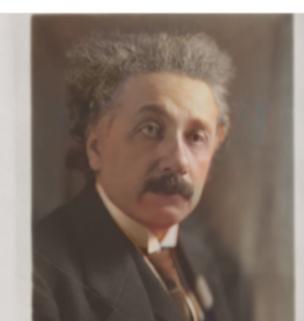
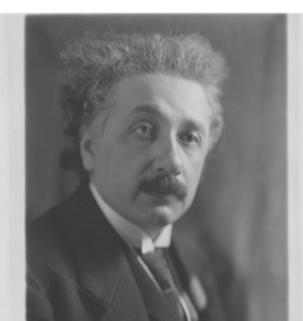
— HAROLD COHEN, 1989



The first color image created by AARON at the Computer Museum, Boston in 1995

AI Colorization

- Up until the mid-1940s, photographs were in black and white due to limitations in the understanding of optics and technologies
- Take a grayscale image as input and output a colorized version of it



Booker T. Washington

Amelia Earhart

Teddy Roosevelt

Helen Keller

Albert Einstein

Dolores del Rio

Colorization History

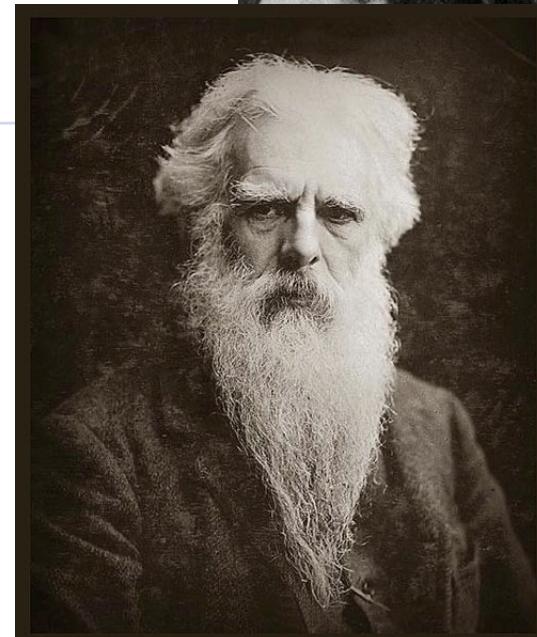
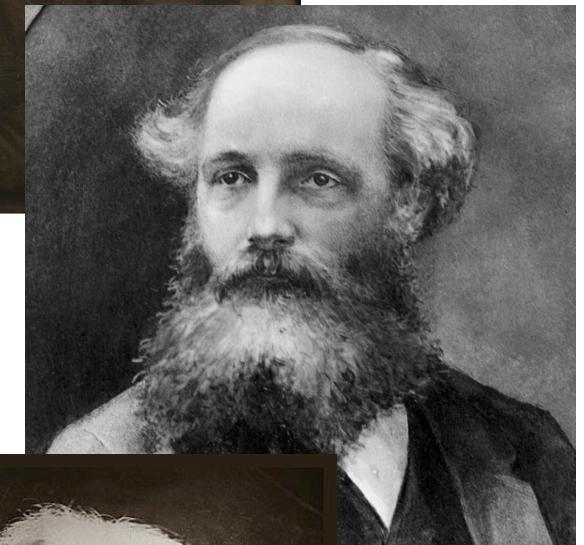
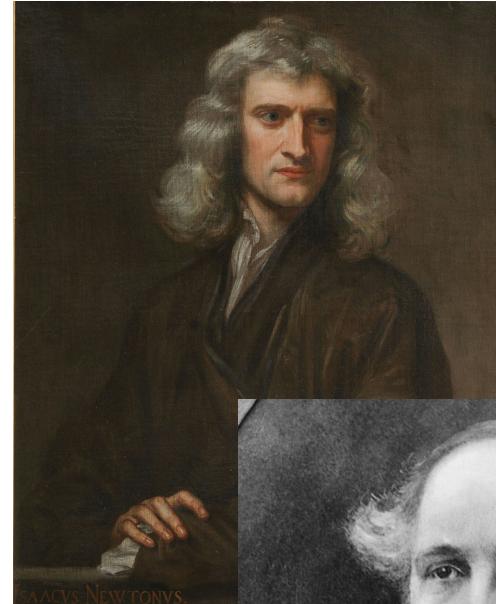
Isaac Newton began a series of experiments with sunlight and prisms. He demonstrated that clear white light was composed of seven visible colors.

1666

1861

1872

James Clerk Maxwell and photographer Thomas Sutton took the first color photo

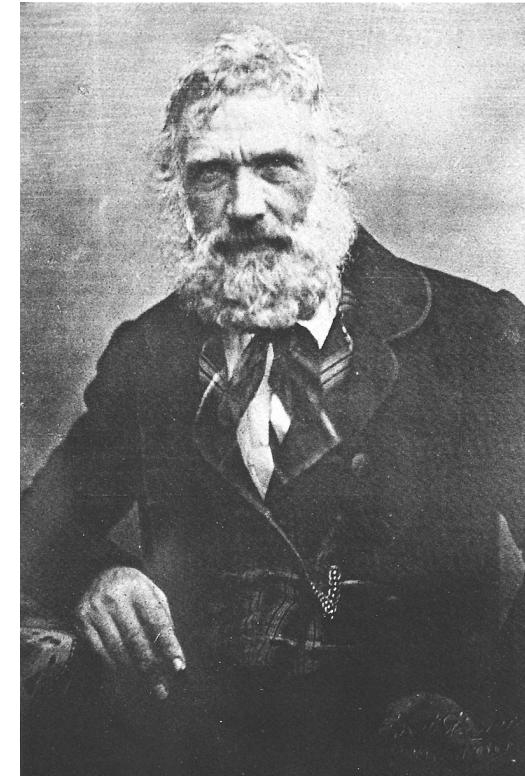


Coloring photographs by hand

- Johann Baptist Isenring (1893) developed a coloring method for his proofs, which he patented in America
- Produced the first colored daguerreotype using a mixture of gum Arabic and pigments



The Königssee at Berchtesgaden (1823)



Johann Baptist Isenring (1796-1860)

First Computer-assisted Colorization

- Wilson Markle described a computer-assisted process for film colorization in 1970s
- His first company, Image Transform, colored pictures from the Apollo space program to make a full-color television presentation for NASA.



Wilson Markle (1938-2020)

Patent 1291260 Summary

Third-party information liability
Claims and Abstract availability

| | |
|--------------------------|---|
| (12) Patent: | (11) CA 1291260 |
| (21) Application Number: | 552277 |
| (54) English Title: | COLORING A BLACK AND WHITE SIGNAL USING MOTION DETECTION |
| (54) French Title: | COLORISATION DE SIGNAUX D'IMAGERIE MONOCHROME UTILISANT LA DETECTION DES MOUVEMENTS |

Bibliographic Data | Abstracts | Claims | Description | Representative Drawing | Admin Status | Owners on Record | Documents

English Abstract

ROGERS, BERESKIN & PARR

Inventors: Wilson Markle and Brian Hunt

Title: Coloring a Black and White Signal

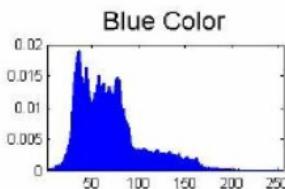
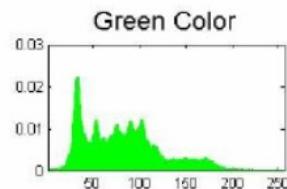
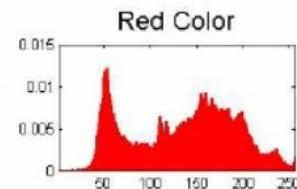
Using Motion Detection.

ABSTRACT OF THE INVENTION

A method and apparatus for coloring a black and white film. The film is converted to video tape and the locations of edges of moving objects in frames of the video signal are used to develop a motion indicator key. The motion indicator key is used to reduce noise in the video signal without smearing motion and is used to assign colors to the black and white signal. For each scene of the black and white film, a color mask is produced for one frame. The adjacent frame is then colored the same as the initial frame except where motion is indicated. Where motion is indicated, a selected process assigns colors, for example based on direction of movement or grey levels of adjacent pixels. The new color mask thus produced is used as a reference for coloring the next frame. In this way the whole film may be colored, scene by scene. The color mask produced may then be combined with the black and white video signal to produce a colored video signal.

Early 2000s

- Early computer-assisted method: **Texture synthesis**
- This approach matches the **three-dimensional distribution** (RGB) of color values between the images and then transforms the color distribution of the target image to match the distribution of the source image
- Advances in signal processing and wavelets by Ingrid Daubechies



+



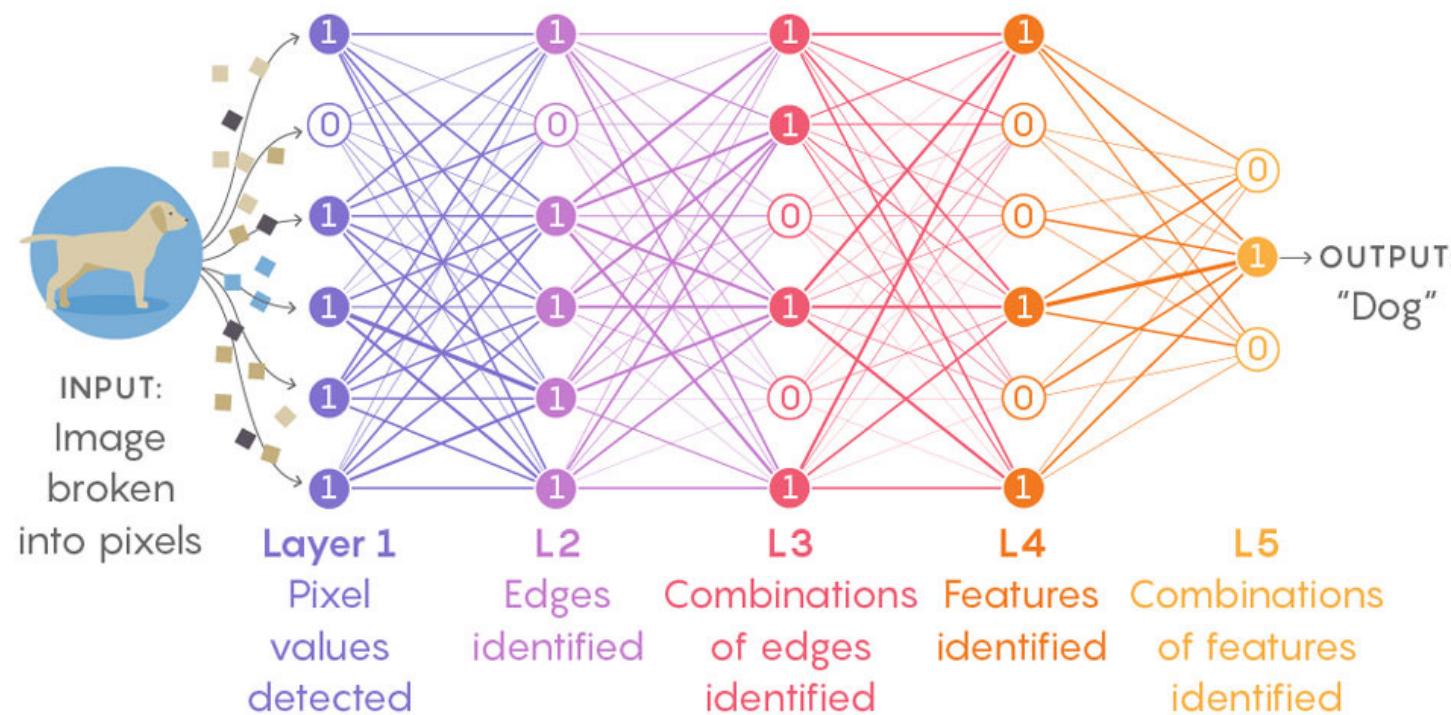
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Recall: Deep Learning

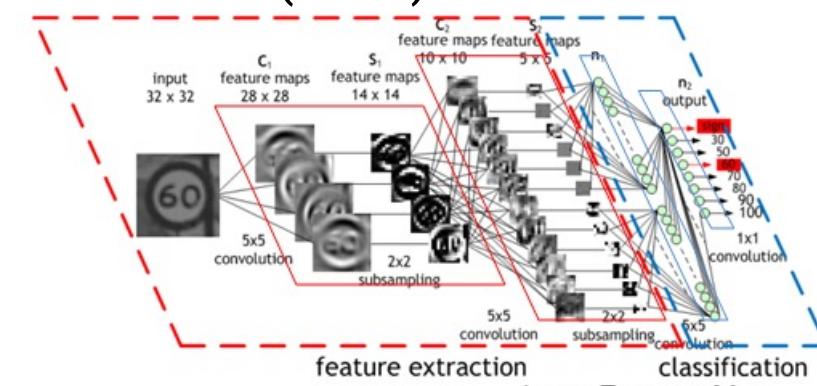
Learning From Experience

Deep neural networks learn by adjusting the strengths of their connections to better convey input signals through multiple layers to neurons associated with the right general concepts.



Deep Learning: Convolutional Neural Networks

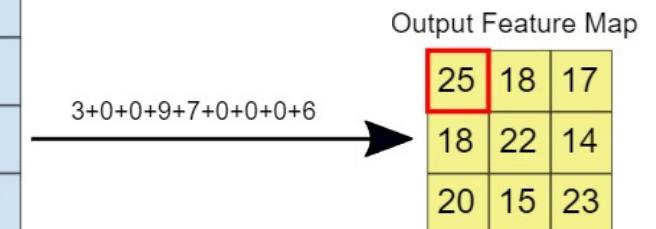
- **Convolutional Neural Network (CNN)**: a number of convolutional layers to filter inputs for useful information (extract features)
- The convolution operation involves combining input data (feature map) with a **convolution kernel** (filter) to form a transformed feature map.



| Input Feature Map | | | | |
|-------------------|---|---|---|---|
| 3 | 5 | 2 | 8 | 1 |
| 9 | 7 | 5 | 4 | 3 |
| 2 | 0 | 6 | 1 | 6 |
| 6 | 3 | 7 | 9 | 2 |
| 1 | 4 | 9 | 5 | 1 |

| Convolutional Filter | | |
|----------------------|---|---|
| 1 | 0 | 0 |
| 1 | 1 | 0 |
| 0 | 0 | 1 |

| Input Feature Map | | | | |
|-------------------|-----|-----|---|---|
| 3x1 | 5x0 | 2x0 | 8 | 1 |
| 9x1 | 7x1 | 5x0 | 4 | 3 |
| 2x0 | 0x0 | 6x1 | 1 | 6 |
| 6 | 3 | 7 | 9 | 2 |
| 1 | 4 | 9 | 5 | 1 |



Deep Learning-based Colorization

- Computational pipeline for **classification, detection, and segmentation** by CNNs
- Constraints on colorization based on semantic meanings, e.g., the grass is green, the sky is blue, and ladybugs are red



Fig. 1. Example input grayscale photos and output colorizations from our algorithm. These examples are cases where our model works especially well. Please visit <http://richzhang.github.io/colorization/> to see the full range of results and to try our model and code. Best viewed in color (obviously).

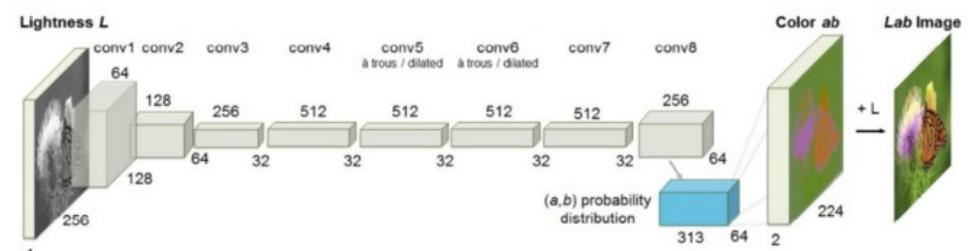
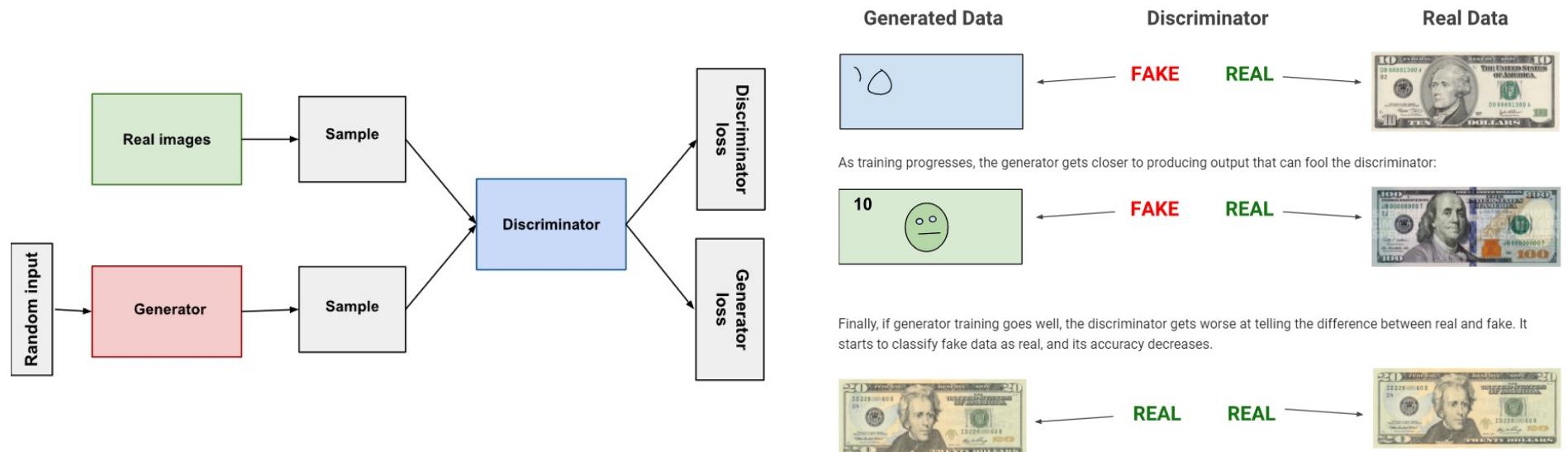


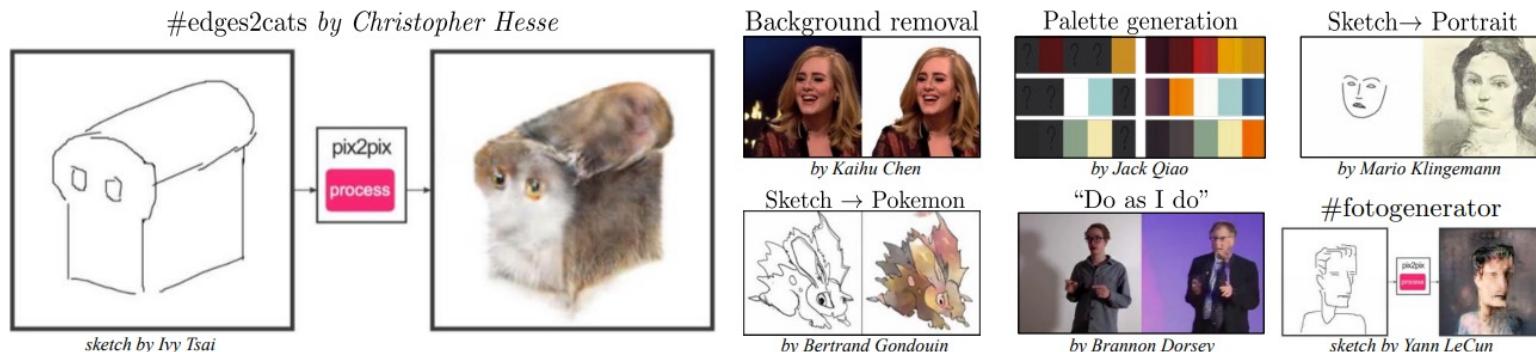
Fig. 2. Our network architecture. Each **conv** layer refers to a block of 2 or 3 repeated **conv** and **ReLU** layers, followed by a **BatchNorm** [30] layer. The net has no **pool** layers. All changes in resolution are achieved through spatial downsampling or upsampling between **conv** blocks.

Deep Learning: Generative Adversarial Networks

- **Generative Adversarial Network (GAN):** Two CNN neural networks play a zero-sum game with each other to create new data resembling the training data

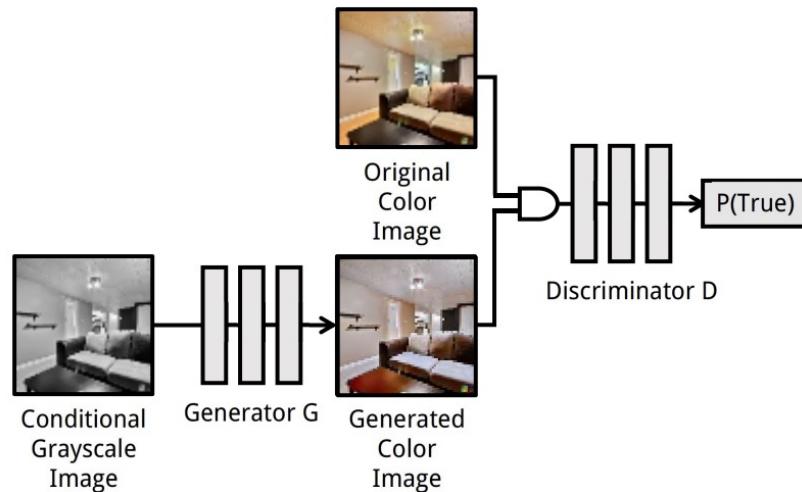


- NVIDIA's StyleGAN: <https://youtu.be/9QuDh3W3lOY>
- Pix2pix: A GANs model for general purpose image-to-image translation



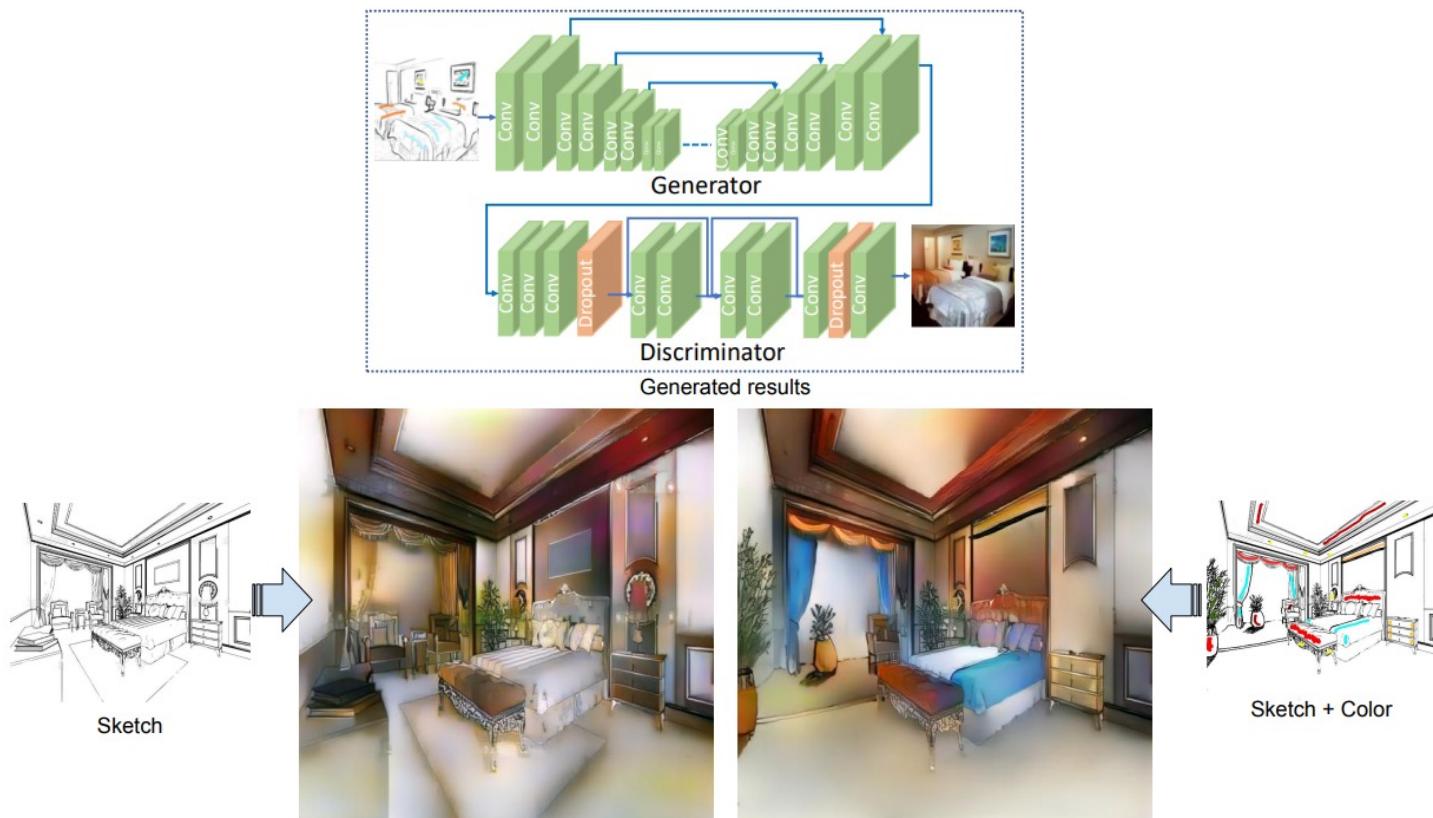
Try GAN-based AI Colorization

- Deep-learning-based AI Colorization: **Deoldify** (<https://deoldify.ai>)
- Software-as-a-Service via DeepAI: <https://deepai.org/machine-learning-model/colorizer>



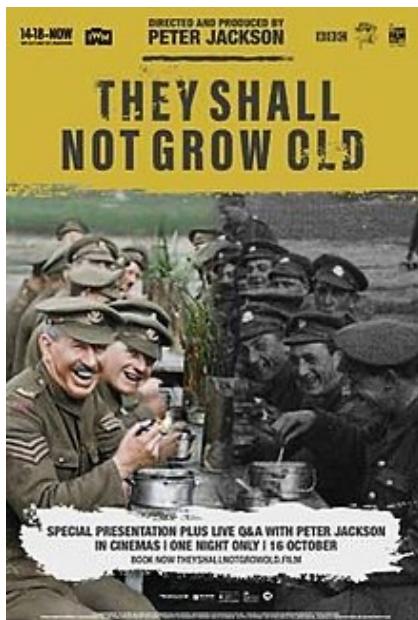
User-Guided AI

- Scribbler: End-to-end feed-forward deep GAN
- User input in the form of sketches and color strokes



AI Colorization of Real-world Footages

- Hindenburg Disaster (2013)
https://youtu.be/ytPToUTd_t0
- They Shall Not Grow Old (2018)- Computer-colorized WWI documentary
<https://www.youtube.com/watch?v=lrabKK9Bhds>

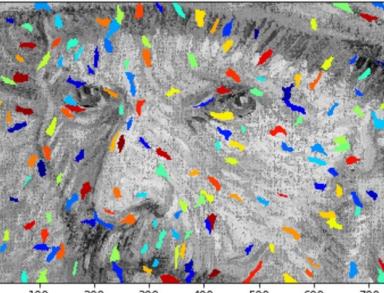
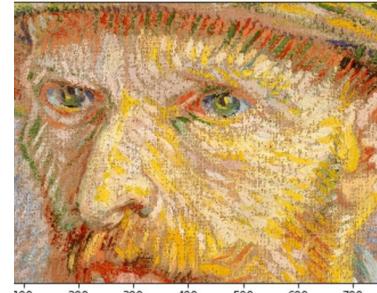
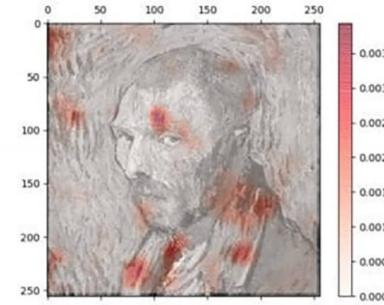
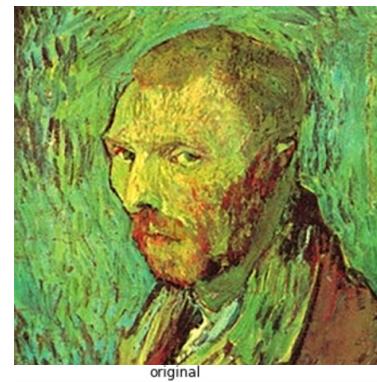
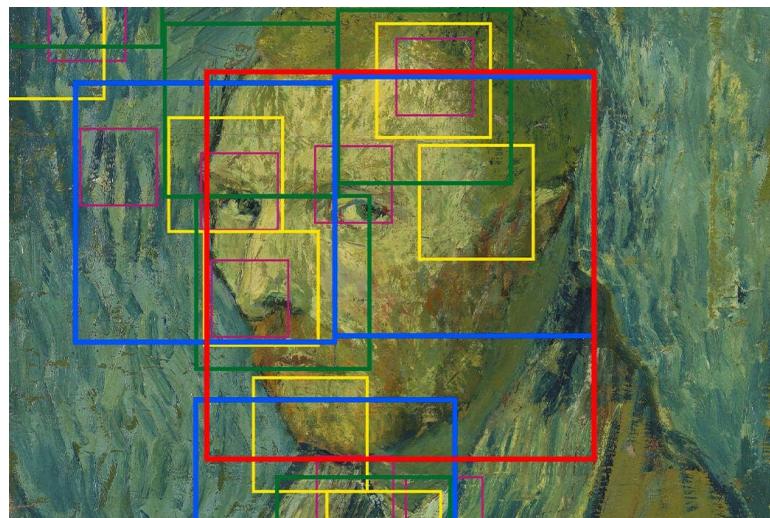


Authenticity and Forgery of Art by AI

- Art forgery is defined as an artwork created with the intent to deceive.
- Can AI verify authenticity of artwork to combat art forgery?
- Can AI forge an original artwork?
- What is AI art?
- How signal processing and AI algorithms can be used to analyze visual art by modeling and extracting features (shape, texture, style, tone, and color) from the artwork (e.g., a painting)?

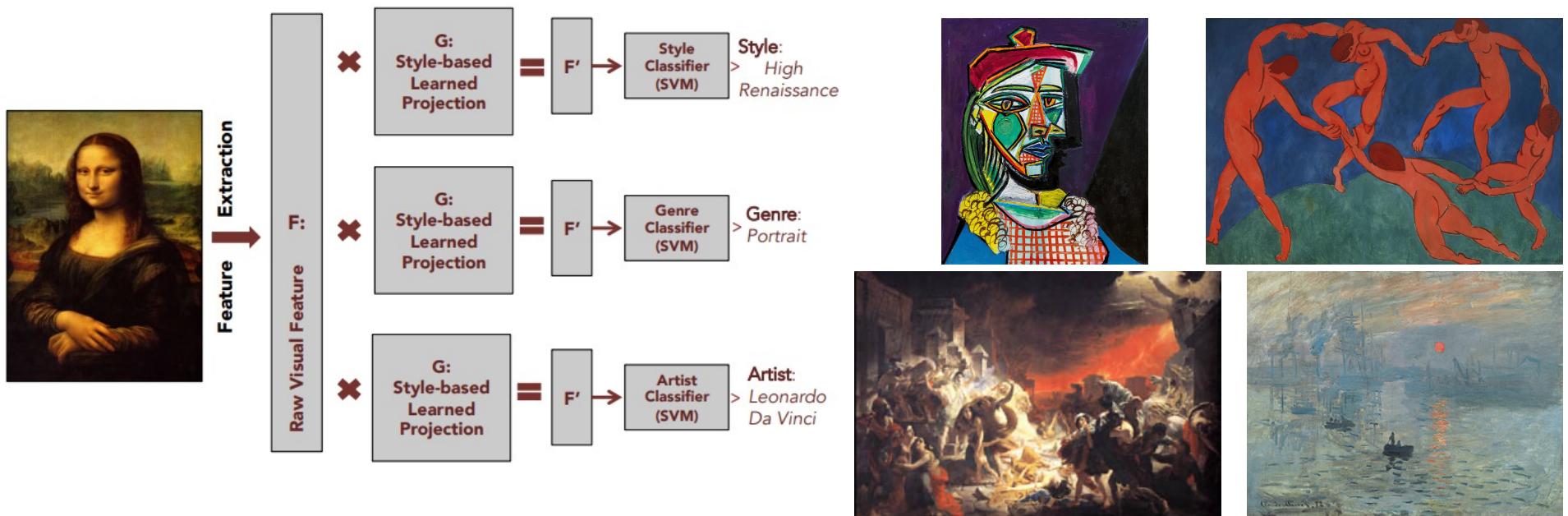
Authenticity and Forgery of Art by AI

- Deep learning models allow one to examine **patterns**, typical structured **features** and the directionality of **brushstrokes**
- In 2019, Art Recognition (<https://art-recognition.com>), a Swiss art authentication company, offers online art authentication services by deep learning



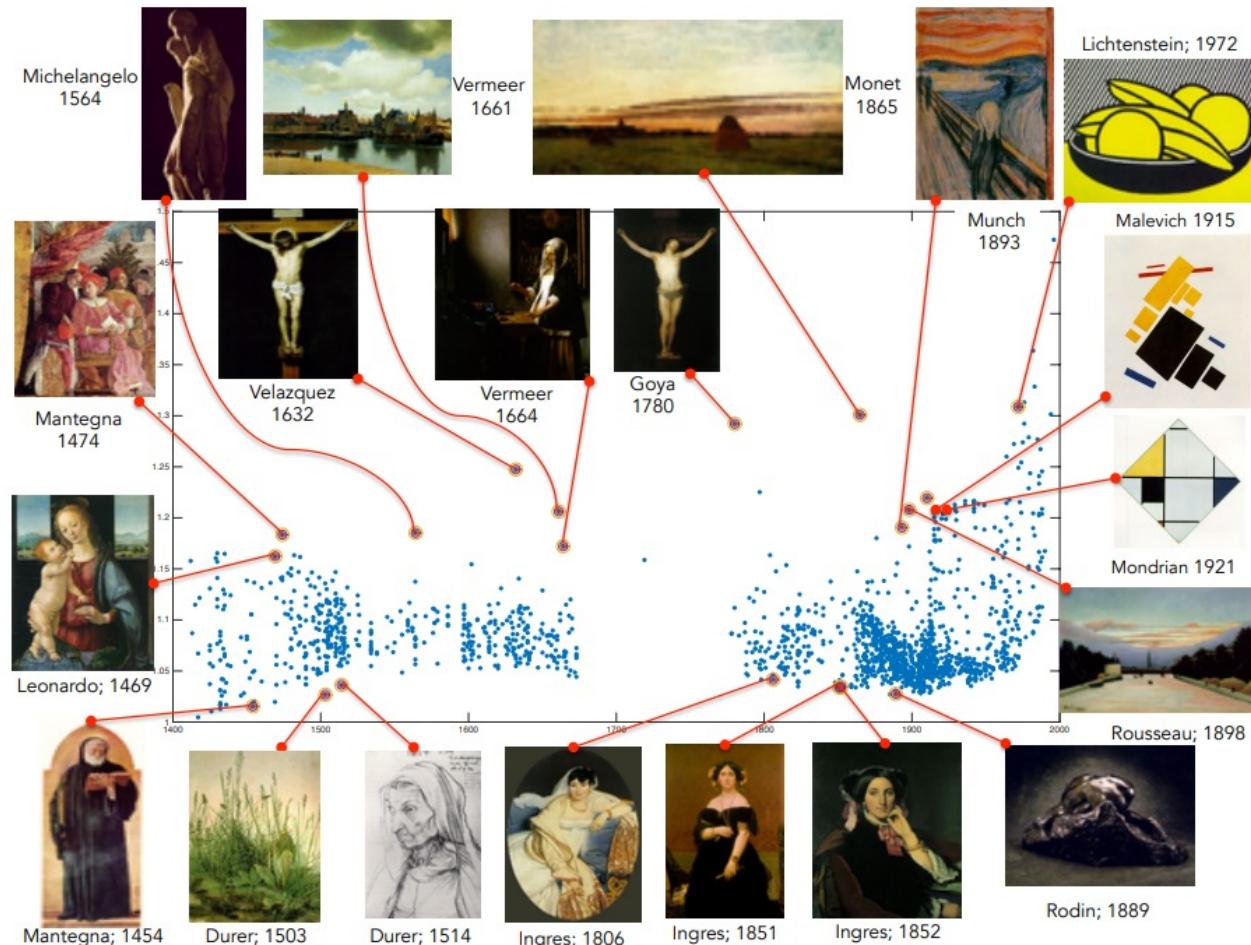
Authenticity and Forgery of Art by AI

- Artistic AI: Analyzing Visual Culture Through the Eyes of a Machine:
<https://www.ipam.ucla.edu/abstract/?tid=13068>
- **Anti-forgery algorithm** by large-scale classification of Western fine-art paintings to analyze stylistic connections among artists, e.g., Picasso vs Matisse, Russian Romanticism vs French Impressionism, Pop art vs the Northern Renaissance.



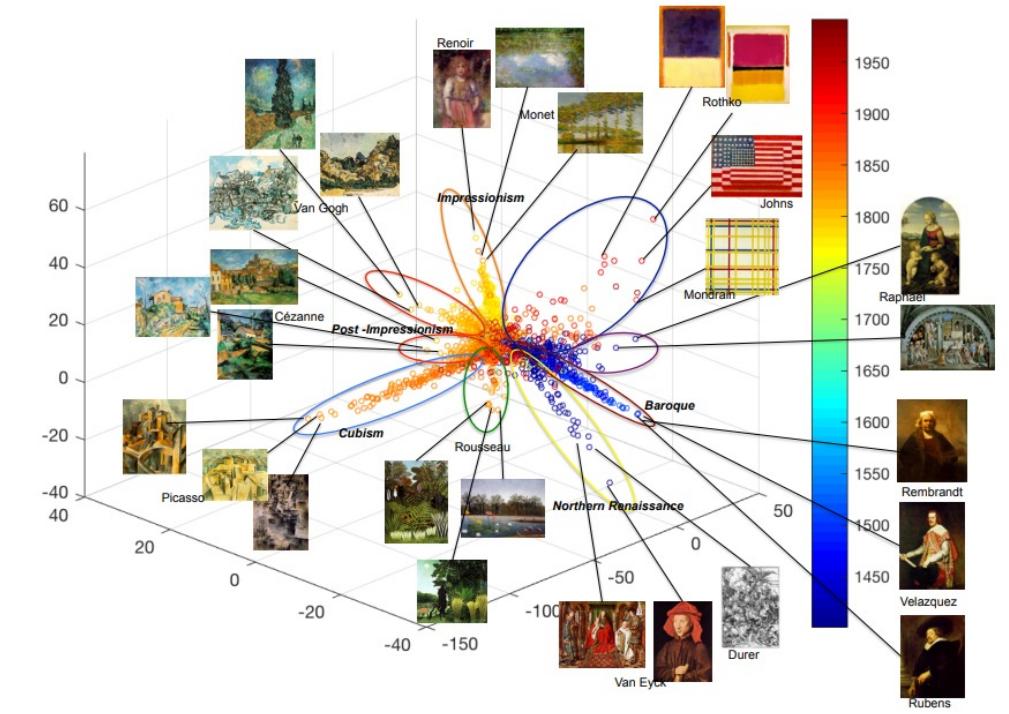
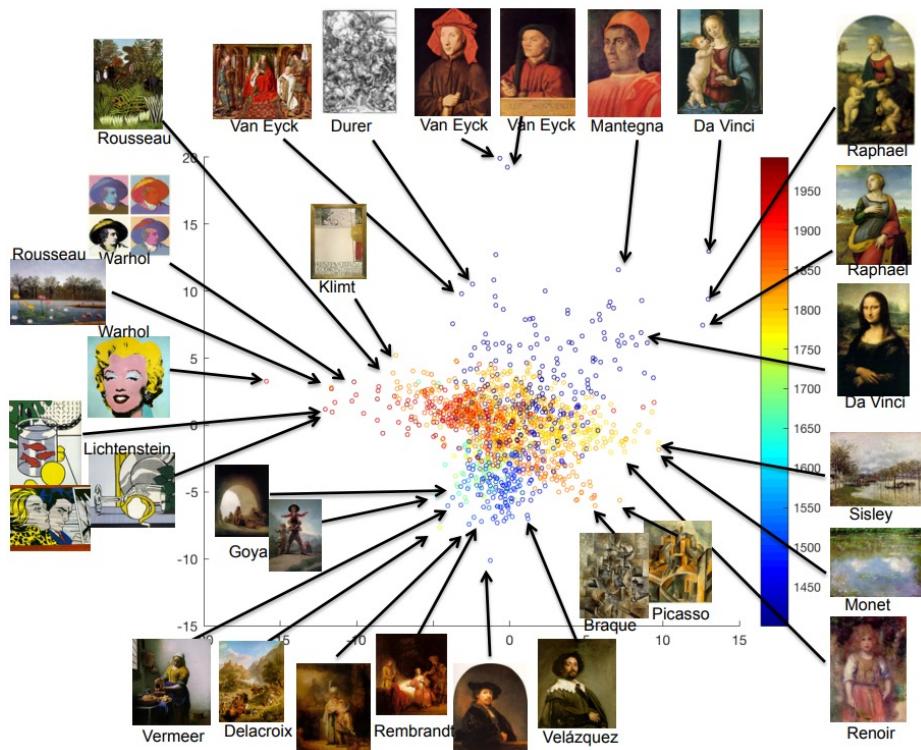
Quantifying Creativity

- Construct a **Creativity Network** connecting artwork and use the Google's Pagerank algorithm to compute **Creativity Scores** to infer the originality and influence of artwork (nodes in the graph)



Style Classification by Stylometry

- Use Convolutional Neural Network (CNN) and Creativity Network to model the learned representation and feature through correlation analysis with findings in art history to assess the evolution of style



Master Forger: Chang Dai-chien

- Chang Dai-chien (張大千, 1899-1983) is regarded as one of the most gifted master forgers of the 20th century
- Can AI forge a painting as good as Chang does?



Chang Dai-chien 張大千



Chang Dai-chien's impressionist artwork fetched 27 million USD in 2021

Ancient Masterpiece or Modern Forgery

- Metropolitan Museum of New York (1997) and British Museum (1961)



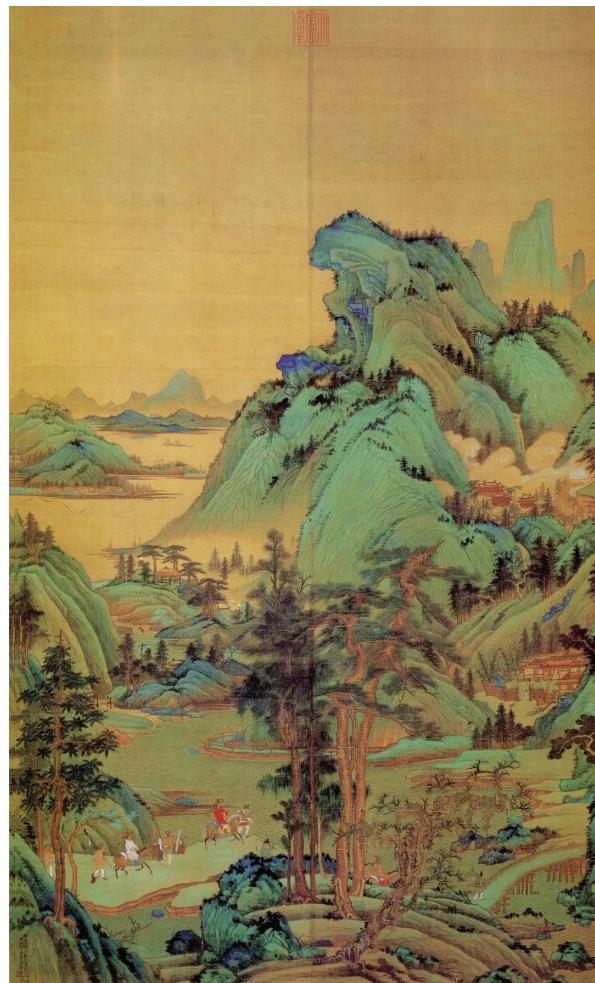
<https://www.metmuseum.org/art/collection/search/39542>



https://www.britishmuseum.org/collection/object/A_1961-1209-0-1

Ancient Masterpiece or Modern Forgery

Riverside View of Splendor (五代董源江堤晚景圖)

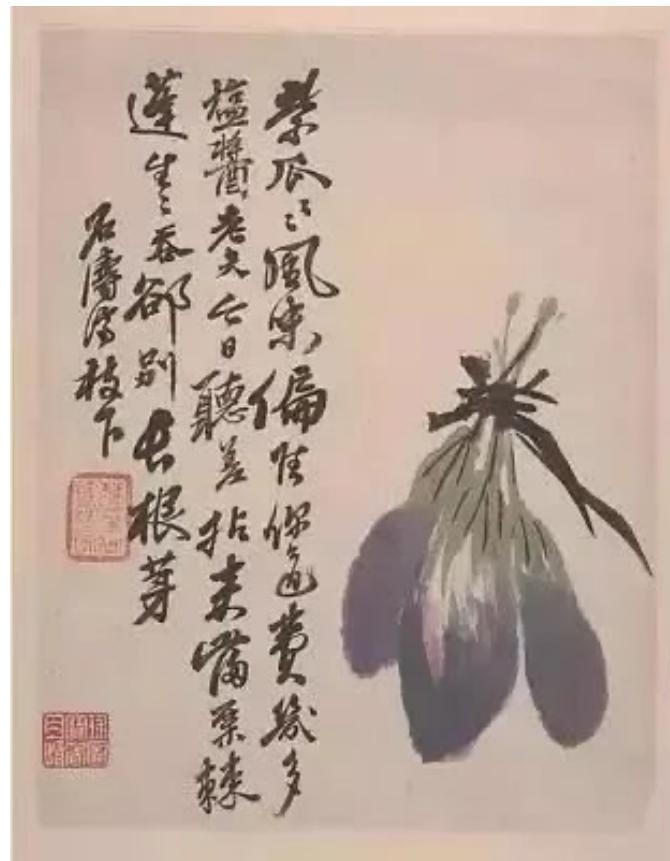


Dong Yuan (934AD-962AD)



Chang Dai-chien's imitation artwork fetched 20 million USD in 2017

Ancient Masterpiece or Modern Forgery



Shi Tao



Chang Dai-chien

Ancient Masterpiece or Modern Forgery



Shi Tao



Chang Dai-chien

Meegeren's Vermeer

- Han van Meegeren (1889-1947) considered one of the most ingenious art forgers of the 20th century forged numerous oil paintings based on styles found in other Vermeer's oil paintings and sold them for profits during the period of WW2
- The Last Vermeer (2020) Movie Trailer: <https://www.youtube.com/watch?v=lc040GtJATc>
- As of 2021, around 36 Johannes Vermeer's oil paintings are classified as real (he probably depicted no more than 60 in all, a paltry number by 17th-century standards as by comparison, his great contemporary Rembrandt produced hundreds of paintings). Are those 36 oil paintings sufficient to enable AI to detect forgery?



"Girl with a Pearl Earring"
by Johannes Vermeer



"The Smiling Girl" by Meegeren,
Vermeer forgery sold to Andrew Mellon in 1926



"A young woman seated at the virginals"
by Vermeer



"The Lace Maker" by Meegeren,
Vermeer forgery sold to Andrew Mellon in 1928

Mark Landis

- Mark Landis (born 1955), the Gift Forger, is best known for 'donating' a large number of forged paintings to American art museums
- Art and Craft (2014) Movie Trailer: <https://youtu.be/f2Alwt2kCro>
- Fakes and forgeries in the art world: <http://www.intenttodeceive.org/gallery/>



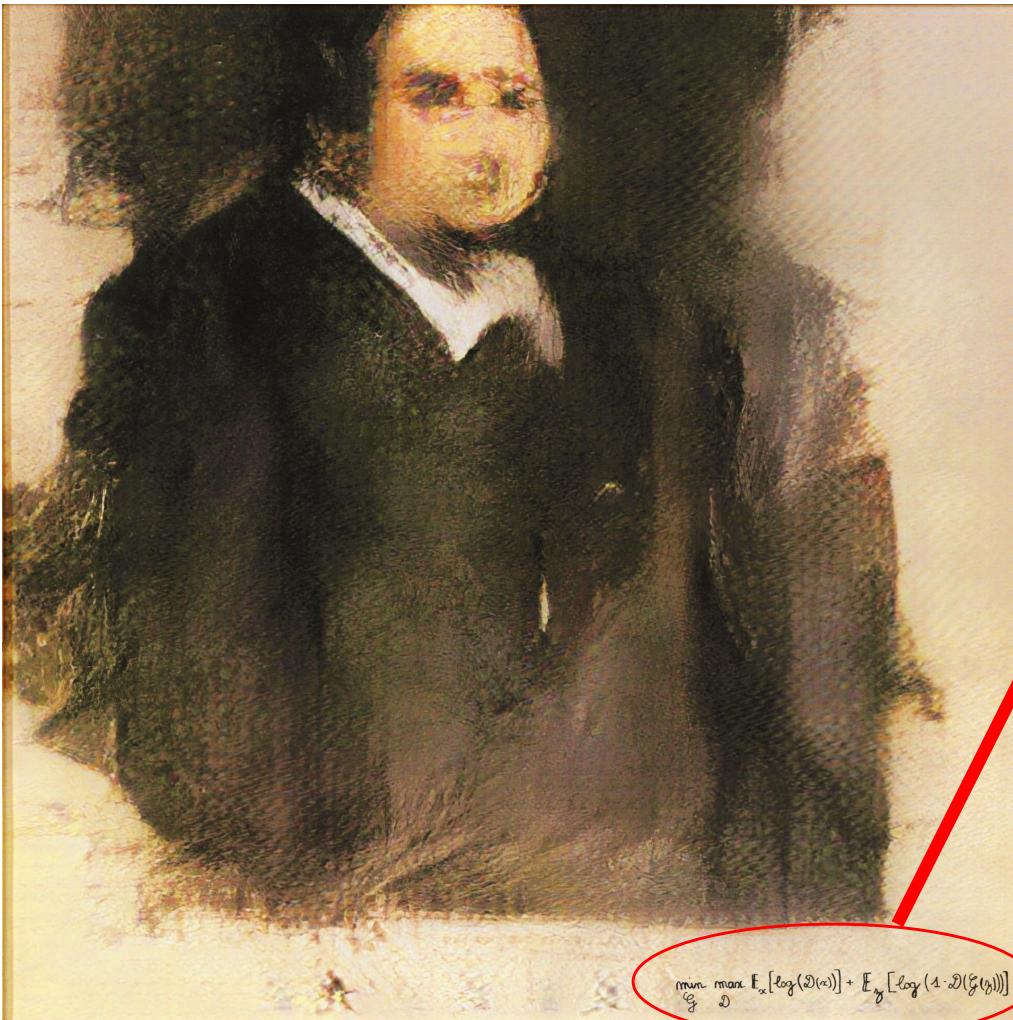
A Mark Landis's copy of an artwork by Paul Signac



Paul Signac's original work

What is AI Art?

- AI-generated painting sold for \$432,500 by Christies in 2018



Edmond de Belamy, from La Famille de Belamy

Price realised
USD 432,500 Estimate
USD 7,000 - USD 10,000

<https://techcrunch.com/2018/10/26/eerie-ai-generated-portrait-fetches-432500-at-auction/>

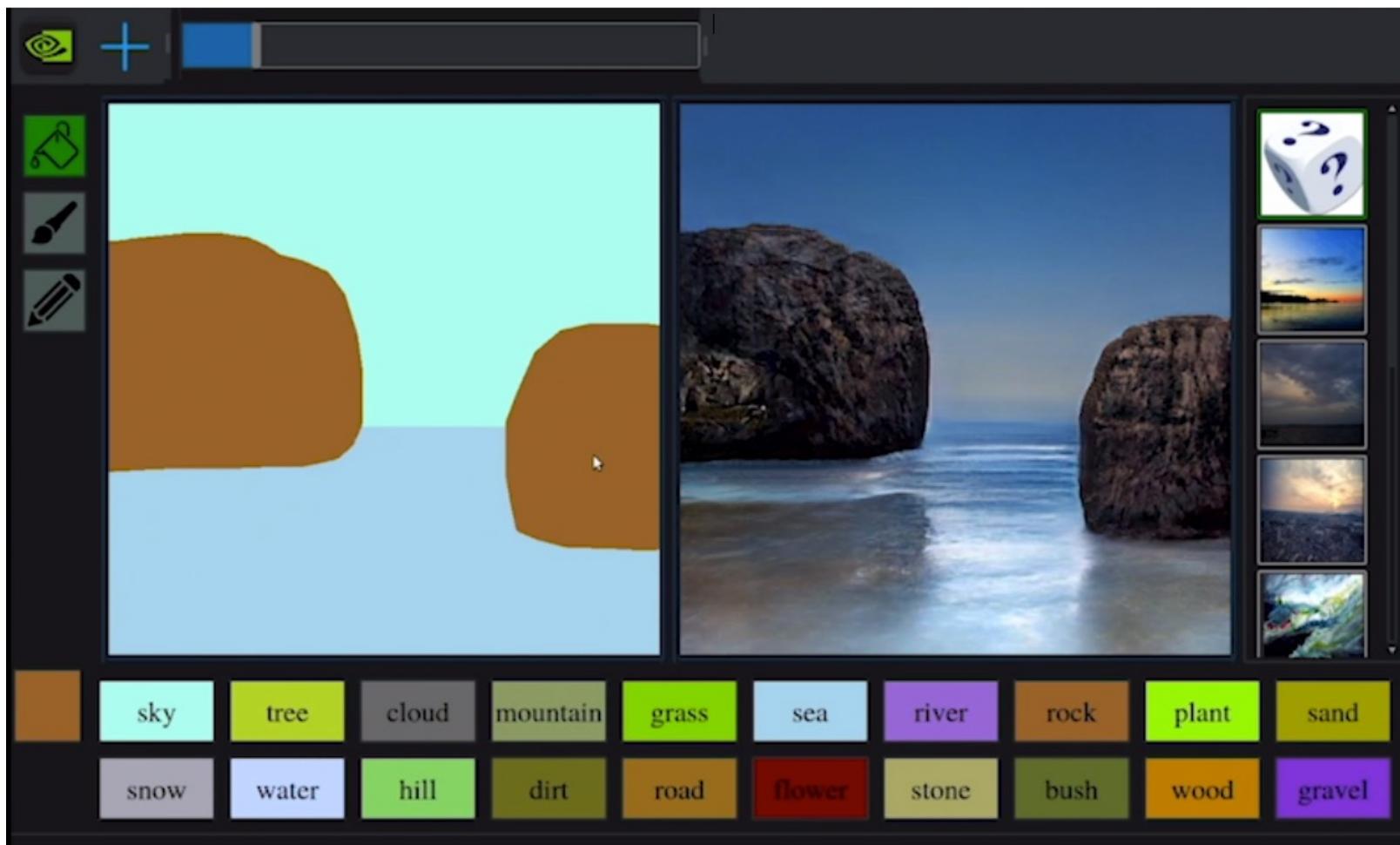
Optimization problem in GAN as a signature:

$$\min_G \max_D E_x[\log(D(x))] + E_z[\log(1 - D(G(z)))]$$

- Online gallery: www.artaigallery.com

What is AI Art?

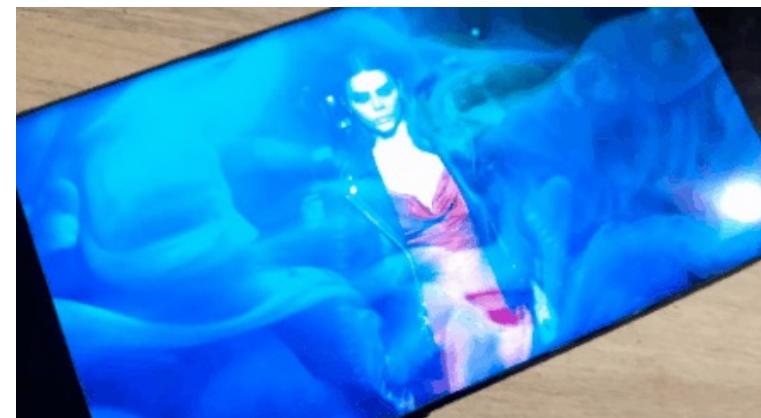
Sketches and automatic image synthesis using deep learning, e.g., Google's Quick Draw (<https://quickdraw.withgoogle.com>), NVIDIA's landscape generation framework GauGAN can turn sketches into landscapes



AI Ethics in AI Art

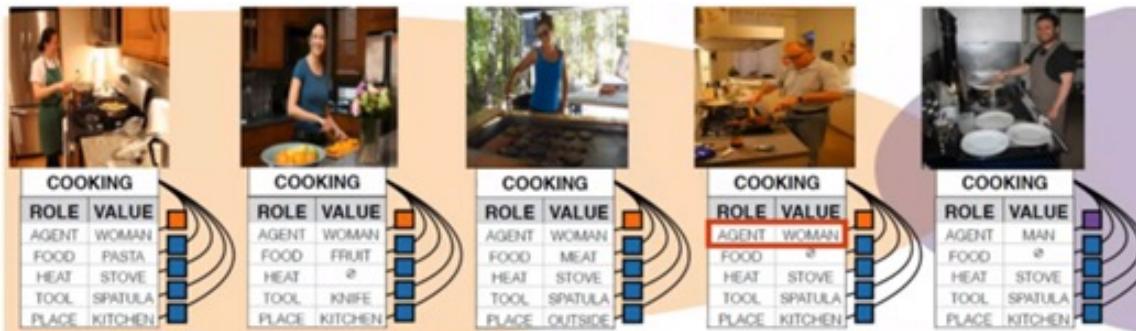
- **Adversarial machine learning:** machine learning technique to cause a malfunction in machine learning models by supplying deceptive input
- **DeepFake:** Use deep learning to create fake items, e.g., FaceSwap app (<https://faceswap.dev>) recognizes and swaps faces in images, videos
- **AI Ethical Issues**
 - Ownership of content or artwork
 - Intent
 - Consideration for aesthetic and monetary value
 - In 2018 the artist Joseph Ayerle published *Un'emozione per sempre 2.0 (The Italian Game)* using DeepFake technology to create an *AI actress*, a synthetic version of 80s movie star Ornella Muti, traveling in time from 1978 to 2018.

Un'emozione per sempre 2.0 (The Italian Game)
<https://www.imdb.com/title/tt13622752/>



AI Ethics in AI Art

- Limitations in deep learning-based neural network models
- Limitations of training set dataset in supervised learning, e.g., few surviving artwork of an artist
- Training set has adversarial data (forggeries), noisy or missing data
- Adversarial machine learning can fool AI models for forgery detection, e.g., how to trust training set since human forgers (past, present) and AI forgers (in future) can forge Chang's artwork due to its lucrative value.
- Do you buy an AI artwork if you are a buyer? At what price?
- Do you have trust in AI forgery detection if you are a buyer?



Data set: 67% of people cooking are women

Algorithm predicts: 84% of people cooking are women



"zombie hand" Colorization