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Session 5

Art NFTs (Generative Art)

META511: Non-Fungible Tokens (NFTs) and the Metaverse

We are here

1. What is an NFT?

2. Copyright and Provenance in NFTs

3. PFPs

4. Art NFTs

Week 5 ⟶ 5. Generative Art

6. Key considerations in the NFT space

7. Gaming NFTs

8. What is a metaverse?

9. Trends in visualization technology

10. Financing models for NFTs and the metaverse

11. Off-chain objects and the broader environment

12. A vision for the future

We will explain the concept of generative art

o Define generative art as a visual medium and other applications

o Explore the origins of generative art

o Provide an overview of the generative art history since the 1950s

o Explore the key artists, events, and concepts that have shaped the course of generative art until today

o Showcase examples of on-chain generative art

o Provide a vision for the future of generative art

This is an educational course only

o We will discuss various projects, individuals or NFTs in this course

o These projects, tokens or the individuals associated with them, are only referenced for educational purposes

o Nothing in this course should be taken as a recommendation to buy or sell an NFT or token or any other financial instrument or security

o More generally, cryptoassets are extraordinarily volatile investments. Please take care if you are buying cryptoassets

o The information provided during this session does not, and is not intended to, constitute legal advice.

o Instead, all information, content, and materials made available is intended for general educational purposes only.

Session 5: Art NFTs (Generative Art)

1. History of Generative Art

Definition

'*Generative art refers to any practice where the* artist *uses a* system, *such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is* set into motion with some degree of autonomy *contributing to or resulting in a completed work of art.*'

Philip Galanter

Aeolus, **king of the winds**

Aeolian harp

Produces enchanting harmonies when the wind passes over it. According to Homer, it was the god Hermes who invented the harp, by having the wind blow over the dried sinews attached to the shell of a dead tortoise.

Source: 1. philipgalanter.com

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Definition

o One overly simple but useful definition is that generative art is art programmed using a computer that intentionally introduces randomness as part of its creation process // **Artnome**

o Clusters of generative art activity examples:

- Electronic Music and Algorithmic Composition
- Computer Graphics and Animation
- The Demo Scene and Video Culture
- Industrial Design and Architecture
- On-Chain Generative Art & Photography

Sources: 1. philipgalanter.com; 2. Ellsworth Kelly's 'Spectrum Colors Arranged by Chance,3.Why Love Generative Art?

Origins of Generative Art

o Generative art positions itself in continuity with the artistic movements of the 20th century.

o As a movement, generative art evolved after modern art avant-guarde experiences praising the chaos and unpredictability, from Dadaism to Surrealism.

o The emphasis on machine aesthetics that we observe in Futurism and Bauhaus permeates generative art.

o The fragmented geometry of Analytical Cubism also plays an important role.
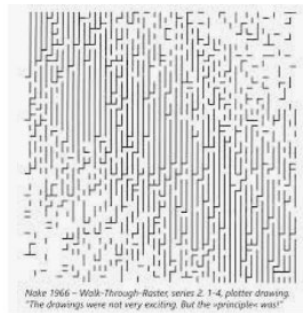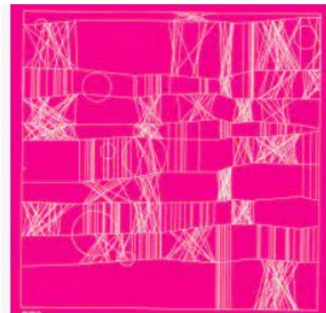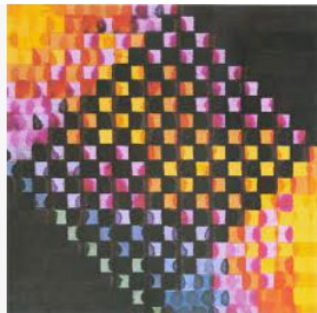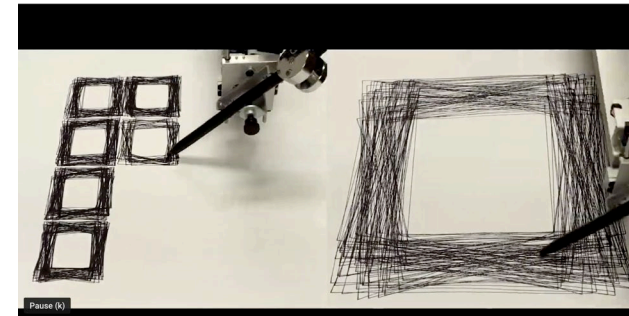
o The first-ever curated exhibition of generative artworks was hosted in 1965 in Stuttgart, showcasing works by **Georg Nees** and garnering significant success.

o A few months later, Nees and **Frieder Nake** – another pioneer in this field – displayed their works together in another exhibition. This show featured pieces programmed and produced by a computer-controlled drawing machine.

Sources: 1. A Whirlwind History of Generative Art: from Molnár to Hobbs; 2. dam.org 3.DRAWING MACHINE 03 | Generative art drawing

Origins of generative art

○ At that time, the trailblazers in the US were **Michael Noll and Béla Julesz**, two scientists at Bell Laboratories. They held their exhibition 'Computer-Generated Pictures' at the Howard Wise Gallery.

- Noll created algorithms that generated the images in his works: this was his focus. He injected variety by attributing different parameters to the algorithms.

- Julesz's work, on the other hand, focused on creating random-dot patterns generated by a computer.
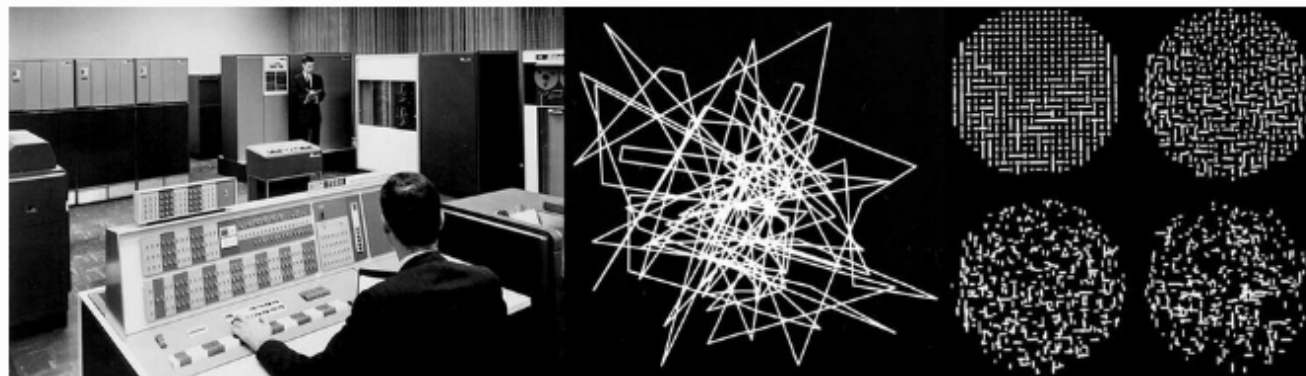
Source: 1. aiartists.org

Origins of generative art: Harold Cohen

o British-born artist who was noted as the creator of **AARON:** a **computer** program designed to **produce art autonomously**.

o His work in the intersection of computer AI and art attracted a great deal of attention, leading to **exhibitions at many museums, including the Tate Gallery in London, and acquisitions by many others.**

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Origins of generative Art: Harold Cohen

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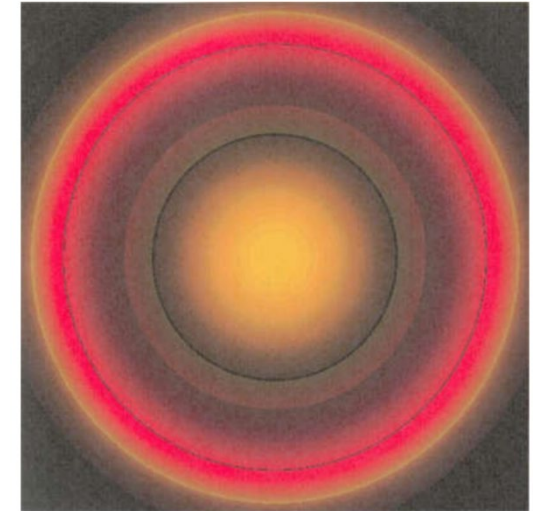
Origins of generative art: Herbert Franke
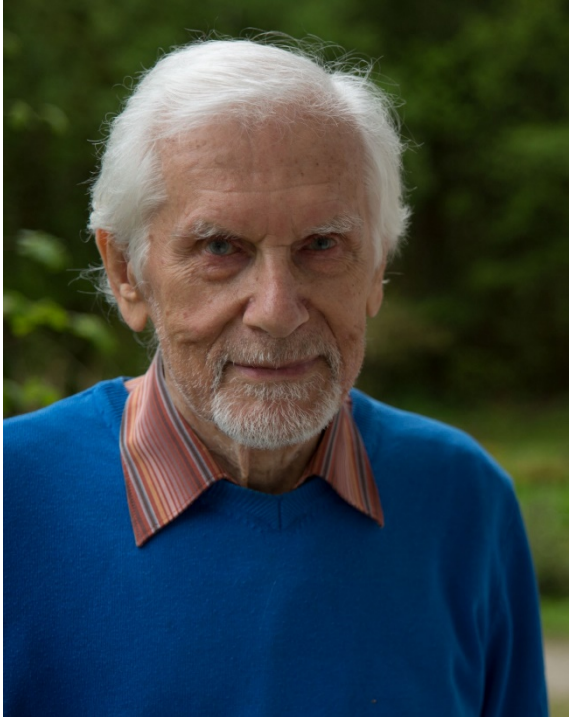
- Herbert Franke used algorithms and computer programs to visualize mathematics in the form of art.

- His early works revolved around generative photography, and analog computers. He also used the first mainframe computers in the 1950s and 1960s to produce abstract algorithmic art.

- The Venice Biennale included a screen print from his SQUARE series in 1970.

- Co-founder of Ars Electronica, the largest festival of new media art in the world, in Linz in 1979.

Source: https://medium.com/the-link-art-blocks/ab-101-historical-figures-in-generative-art-herbert-w-franke-48911e977096

Origins of the generative art: Herbert Franke
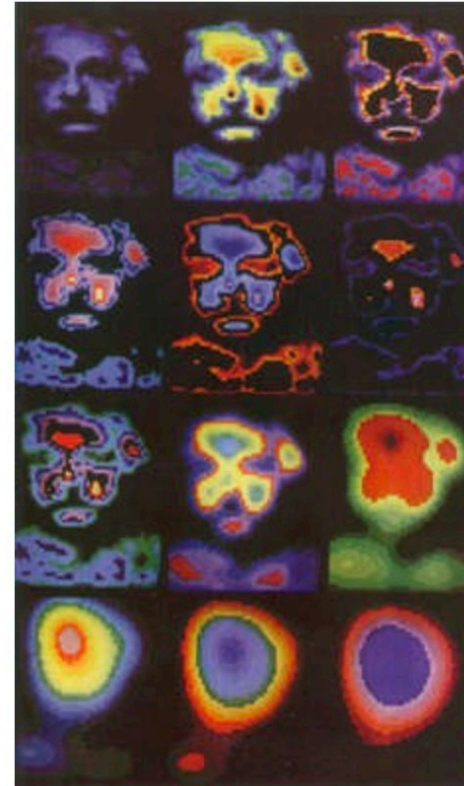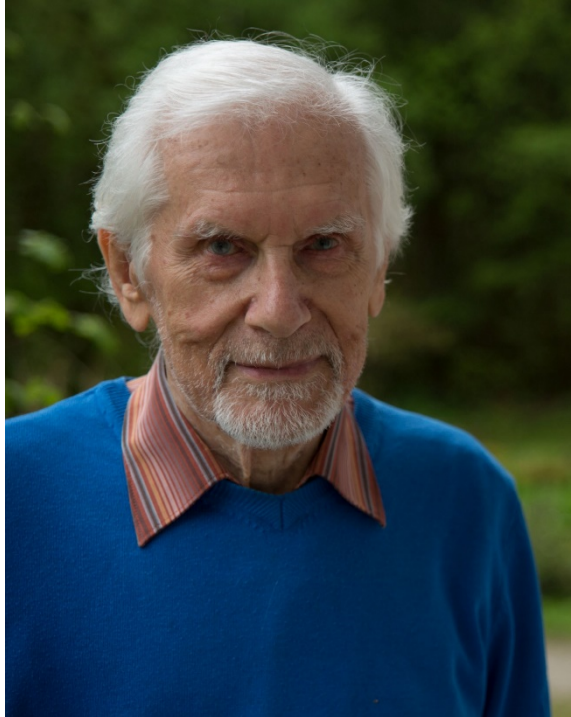
Electronic Einstein (1972)

Computer Science Art (1980)
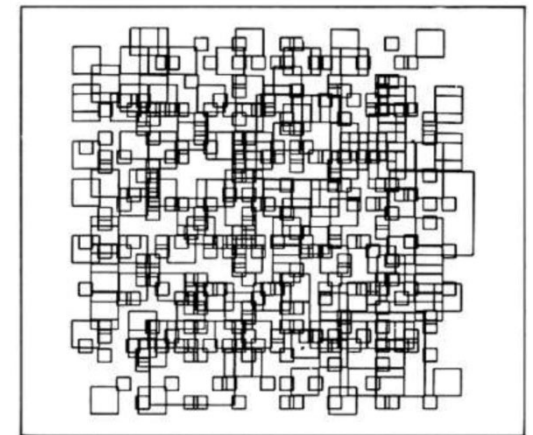
Random Square (1976)

Source: https://medium.com/the-link-art-blocks/ab-101-historical-figures-in-generative-art-herbert-w-franke-48911e977096

Michael Noll and Béla Julesz

A. M. Noll, Vertical-horizontal No.3, "Computer-Generated Pictures" Howard Wise Gallery./A.M. Noll, Gaussian quadratic, "Computer-generated pictures", Howard Wise Gallery.

Computer Composition with Lines, A.M. Noll, 1964, Victoria and Albert Museum. *3D_Julesz*, B. Julesz, 1960.

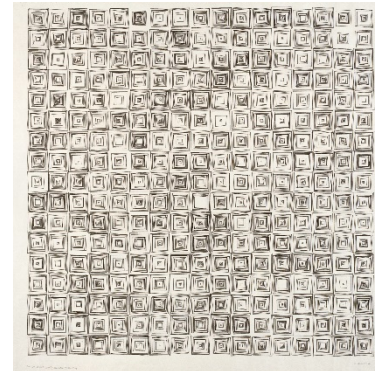Source: https://www.crysalis.art/digital-crypto-art-research/a-whirlwind-history-of-generative-art-from-molnr-to-hobbs
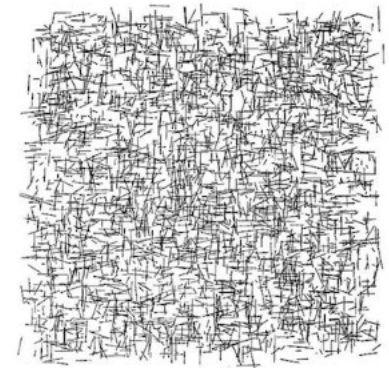
Ellsworth Kelly

o Unlike Nees or Noll, who had scientific backgrounds, the first pure artist to approach the modern generative art practice was Ellsworth Kelly.

o In 1951, Kelly created a series of collages arranged in a mathematical system. A result is an organic form, a complex structure of intertwined colours.

E. Kelly, Spectrum colours arranged by chance II, 1951, MoMA, copyright 2022
Ellsworth Kelly / E. Kelly, Spectrum colours arranged by chance IV, 1951, Art
Institute Chicago, copyright 2022 Ellsworth Kelly.
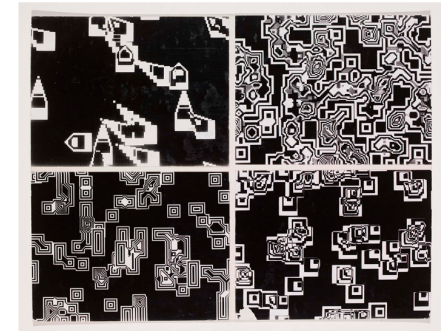
Source: https://www.crysalis.art/digital-crypto-art-research/a-whirlwind-history-of-generative-art-from-molnr-to-hobbs

Non-Fungible Tokens (NFTs) and the Metaverse
Session 5: Art NFTs (Generative Art)

Vera Molnár

o Molnár is a Hungarian artist living in France; she's now 98 and still an active creator. She trained in art history and aesthetics and co-founded the Groupe de Recherche d'Art Visuel in 1960.

o **'My life is squares, triangles and lines. I am mad about lines'**

o Molnár devoted herself to investigating endless variations in geometrical shapes and lines. In her career, she resorted to the 'Machine Imaginaire', imagining herself to be a drawing machine. Her method consisted of realizing works step by step, following a pre-established programme in a computer-type approach
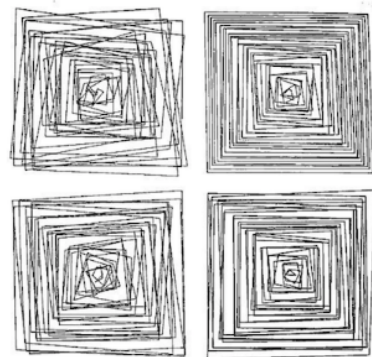
V. Molnár, from the *Carrées non concentriques* cycle, 1974

V. Molnár, *Mondrian Derange*, 1974

Source: https://www.crysalis.art/digital-crypto-art-research/a-whirlwind-history-of-generative-art-from-molnr-to-hobbs

Lillian Schwartz, Ken Knowlton

Pixillation, photographic film stills - Lillian Schwartz, 1970

o Generative artist and art researcher **Lillian Schwartz** worked as artist-in-residence at Bell Labs starting in 1968 for over 34 years. She was the first to have generative art acquired by the MoMA and is often credited, along with her collaborator **Ken Knowlton**, with being the first to exhibit animated digital work as fine art.

Sonia Landy Sheridan, Grace Hertlein, Muriel Cooper

o **Sonia Landy Sheridan**, who founded the first generative systems department at the Art Institute of Chicago in 1970, and **Grace Hertlein**, who helped to popularize the first annual generative art competition when she became arts editor for Computers and Automation Magazine in 1974.

o **Muriel Cooper** had as much influence as anyone in establishing the aesthetics of the computing revolution. She founded MIT's Visual Language Workshop (VLW) in 1975, which moved to the MIT Media Lab in 1985 as "one of its founding sources".

Source: https://www.artnome.com/news/2018/8/8/why-love-generative-art; http://lillian.com/; http://www.kenknowlton.com/

Session 5: Art NFTs (Generative Art)

2. Generative Art NFTs

Randomness // Computer vs Artist

randomness   /ˈrandəmnəs/ noun

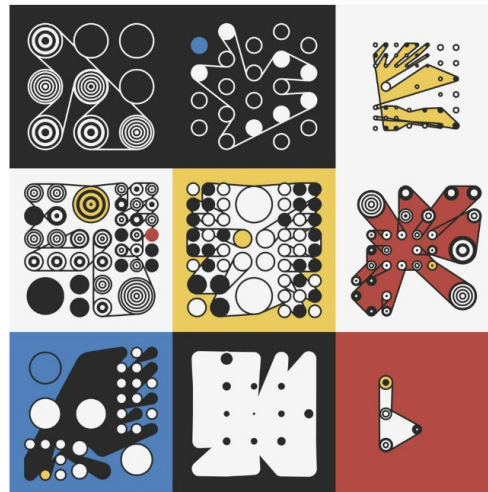The quality or state of lacking a pattern or principle of organization; unpredictability.

"Without the aid of a computer, it would not be possible to materialize quite so faithfully an image that previously existed only in the artist's mind. This may sound paradoxical, but the machine, *which is thought to be cold and inhuman,* can help to realize what is most subjective, unattainable, and profound in a human being.*"*

Vera Molnar

Generative art NFTs

○ Generative art NFTs are pieces of art created through computer code and stored on the blockchain

○ Typically, generative artists create a set of images by adding certain rules to the code, following two main paths: long-form and short-form

What is the difference?

Artist selection of (n) pieces

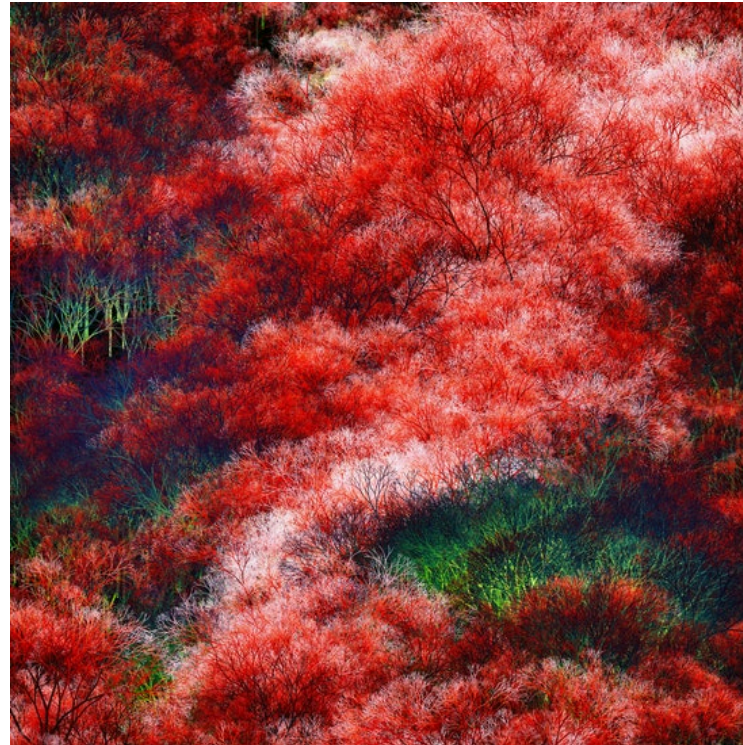Fixed number (n) of fully random outputs

Manoloide

I hope my work is of use to you, just feel free to grab the **code** or the **images** and use it for whatever you want!
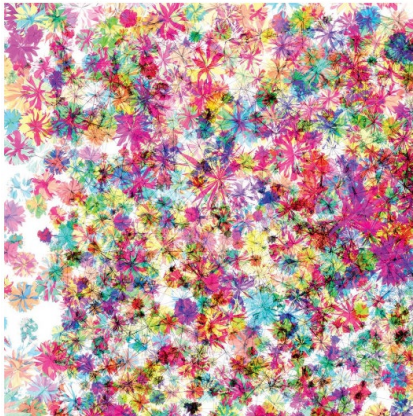
Manoloide
@manoloidee
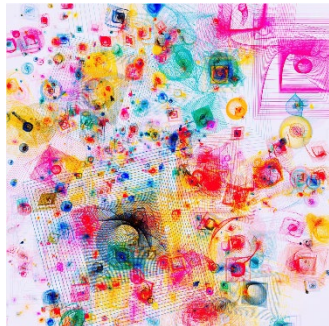
lltt [2021]

arbolito2 [2021]

Mantel amarillo [2021]

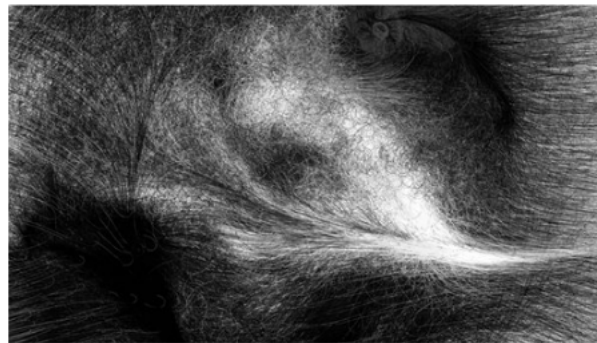**Non-Fungible Tokens (NFTs) and the Metaverse**
Session 5: Art NFTs (Generative Art)

The new generation of generative art

o At the end of the millennium, along with the revolution in personal computing, a new cohort of artists became established in the world of generative art.

o John Maeda, Casey Reas, and Ben Fry are arguably some of the most significant. They took part in the **Aesthetics and Computation Group** at the **MIT Media Lab** under the direction of John Maeda.

o Maeda is a versatile figure who began his career as an engineer, moved to art and design, and then to research and business, tech and investment. Throughout his artistic development, he has redefined electronic media by combining computer programming with traditional creative techniques.

Florale - John Maeda, 1990s

C. Reas, *MicroImage*, 2002-2014

C Reas / Software 16

Source: https://www.crysalis.art/digital-crypto-art-research/a-whirlwind-history-of-generative-art-from-molnr-to-hobbs

Generative art meets NFTs

o Generative art NFTs are created by running a code that produces art; some or all the code output may be then minted into NFTs.

o Artists create a set of images and add certain rules to the code. Then, the algorithm automatically creates the underlying artwork by randomly combining the images or patterns in accordance with the rules set by the artist.

o The code includes specific attributes of varying degrees of rarity, crating different levels of scarcity.
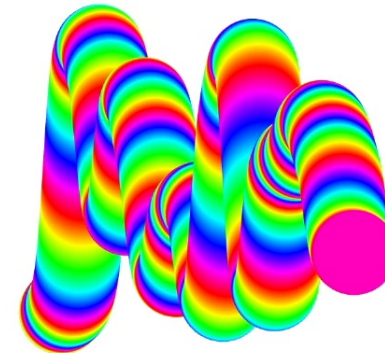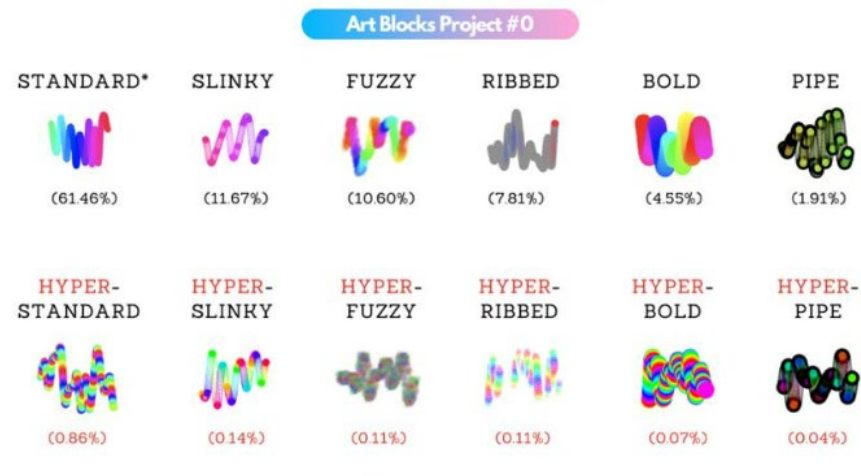
Source: https://www.philipgalanter.com/downloads/ga2003_paper.pdf; https://tylerxhobbs.com/essays/2021/the-rise-of-long-form-generative-art

First well-known on-chain generative art NFT project

o Autoglyphs were the first-ever on-chain generative art NFT project in history

o Canadian developers and Larva Labs founders, John Watkinson and Matt Hall launched Autoglyphs in 2019.

o Based on the Ethereum blockchain, these were originally created by anyone after paying 0.2 ETH (around $35 back then) as the creation fee.

o The artworks pay homage to the pioneers of generative art, Ken Knowlton and Michael Noll.

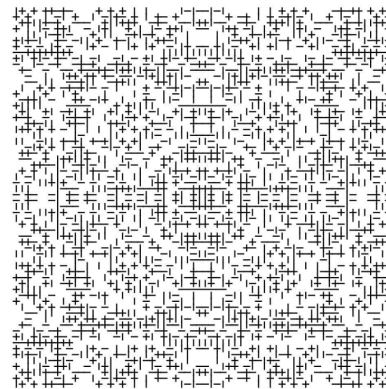o The code has brought together various symbols schemes like +-|, Λ, \|-/, and O|-

Larva Labs   Projects   Writing
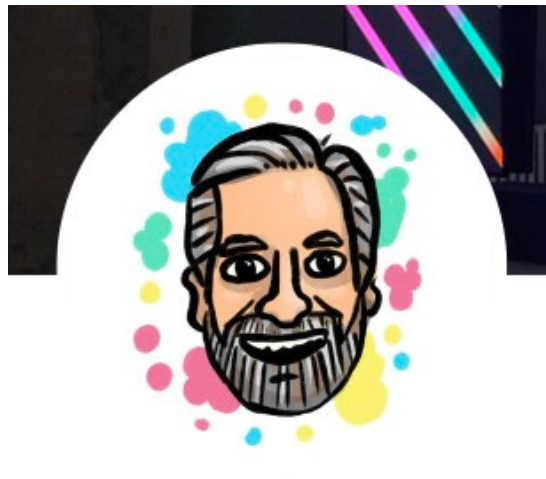
BLOCKCHAIN

Autoglyphs

Autoglyphs are the first "on-chain" generative art on the Ethereum blockchain. They are a completely self-contained mechanism for the creation and ownership of an artwork.

Source: https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts/
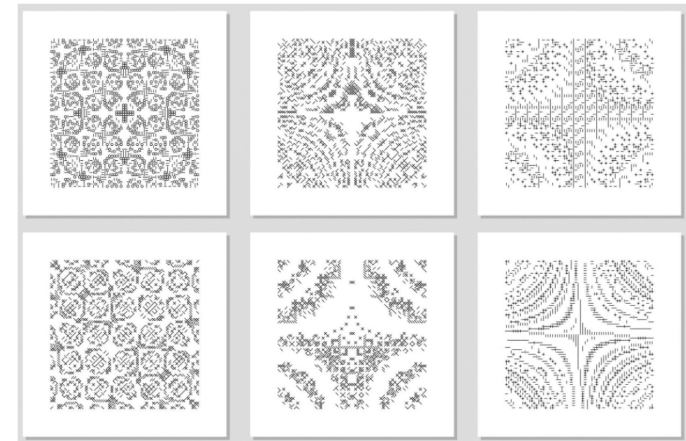
Notable collection: Construction token

#0

Notable collection: Chromie Squiggle

#9671

Art Blocks

Curated

Erick / Snowfro
@ArtOnBlockchain
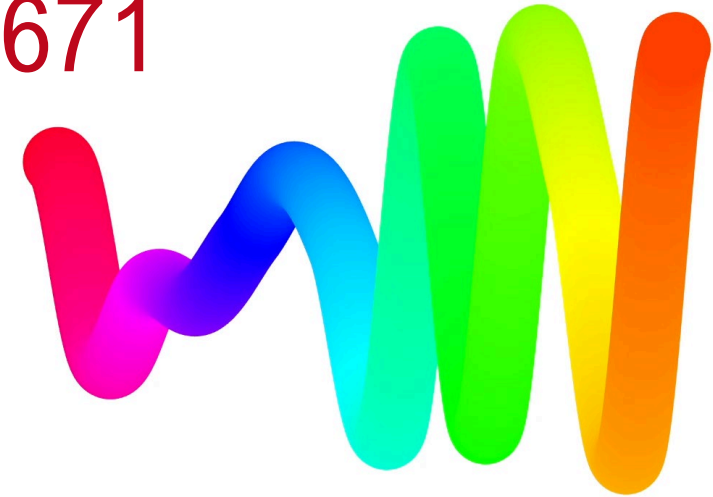
Simple and easily identifiable, each squiggle embodies the soul of the Art Blocks platform. Consider each my personal signature as an artist, developer, and tinkerer. Public minting of the Chromie Squiggle is permanently paused. They are now reserved for manual distribution to collectors and community members over a longer period of time.

Session 5: Art NFTs (Generative Art)

4. On-chain Generative Art

Challenges in the traditional art market

o **Fakes & forgeries**. It is estimated that <u>up to half of the international art market</u> are forgeries and fakes and that even the most sophisticated buyers can be duped. Simply put, the main reason for this is because there has never been an accepted global standard for recording information in the art industry which means that the key information is only sporadically recorded.

o **External dependencies**. Due to the lack of provenance, collectors have had to rely on the opinion of experts and start referring to this as external dependencies to prove authenticity and value. The unfortunate thing about external dependencies is that they are corruptible and prone to error which can lead to enormous discrepancies in value.

o **Provenance:** The artist's name, the creation date, the list of previous owners, previous prices, and the current owner. The record of ownership of a work of art or an antique, used as a guide to authenticity or quality

o **External dependencies.** A person or art curator, a digital art software, a storage system for digital art. to prove authenticity and value. The unfortunate thing about external dependencies is that they are corruptible and prone to error which can lead to enormous discrepancies in value.

Sources: 1. <u>Explaining the Art Market's Thefts, Frauds, and Forgeries</u>; 2. <u>Provenance of Art on the Blockchain</u>

The basic elements in generative art smart contracts

For simplicity, it's important to first define what elements belong in a smart contract that creates a generative art piece:

o **contract** — this is the rules or instructions written by the artists for the computer to follow to create the art

o **unique identifier** — this is the unique genetic code generated at mint (using either pseudorandom inputs from the blockchain such as block hash and number, or something with verifiable randomness such as ChainLink VRF) to create a specific piece of art

Draw function:

o **metadata** — the unique characteristics of the art

o **'draw' function** — the actual tool or canvas that is

being used to create the art

o **images/art** — the final piece of art or the 'output'

```clojure
(defn draw
  []

  (no-loop) ; one frame, don't re-draw
  (set-color-mode) ; use HSB color space

  (background 0 0 100) ; white background
  (stroke 0 0 0) ; black lines
  (no-fill) ; don't fill shape interior

  ; draw a curve with 100 random points
  (begin-shape)
  (dotimes [_ 100]
    (vertex (rand-int (width)) (rand-int (height))))
  (end-shape)

  (save "image.png"))
```
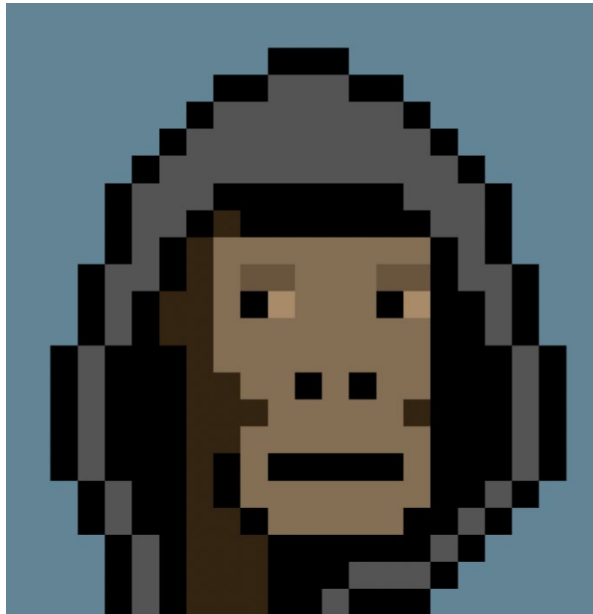
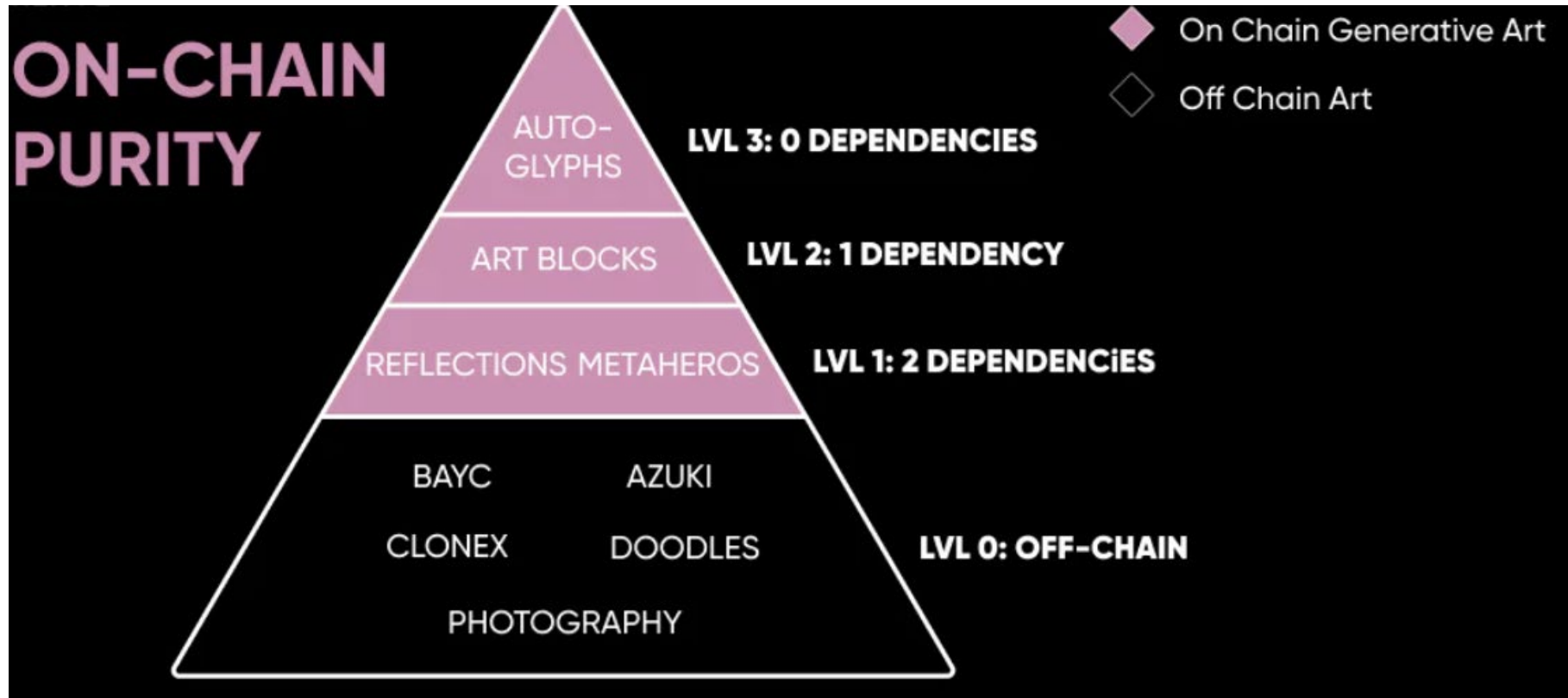Source: ['on-chain purity' in generative art](#)

The turning point of generative art in contemporary times

o NFT projects like <u>CryptoPunks</u> or <u>Bored Ape Yacht Club</u> are all generative art NFT projects. As a matter of fact, most PFP NFT projects fit into this category. However, contrary to common belief, the actual artwork is not stored on the blockchain. Instead, they are stored in a database off-chain.

o There is no guarantee that the images will stay safe there forever.

o **On-Chain Purity** to measure:

- How permanent, transparent, and replicable the art is using the contracts on the blockchain in the long time run
- How much power a developer has, to change the metadata once it is minted on the blockchain

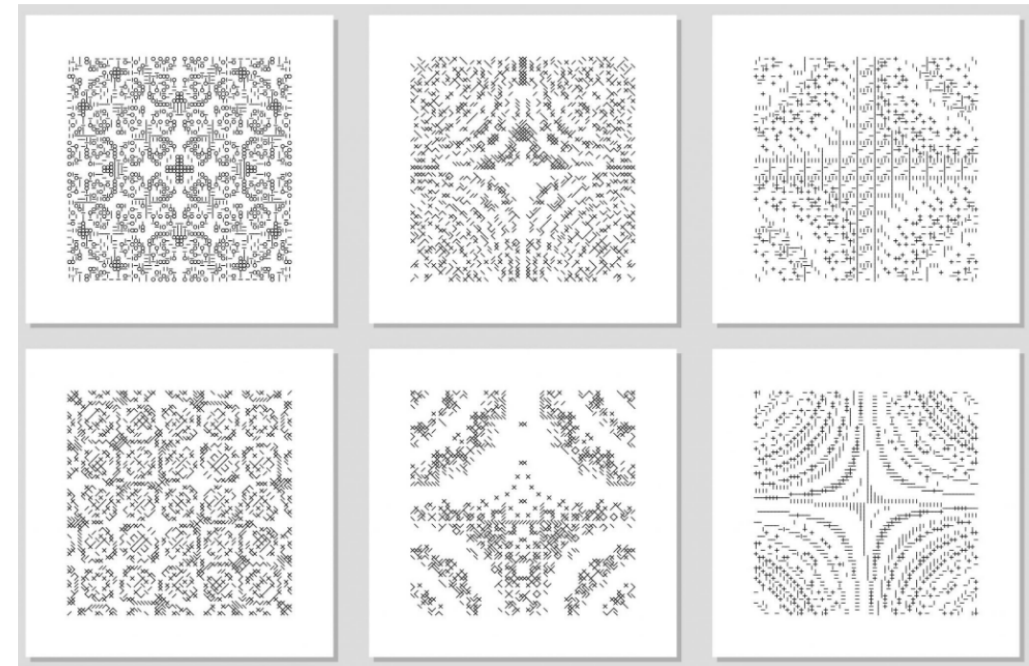Source:<u>https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts</u>/

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# On-Chain Purity

Level 3

○ The ultimate expression of on-chain purity is where all the **data** inc. **images/art**, **contract**, **unique identifier**, **metadata**, and the **'draw' function** is stored all on the blockchain (like Ethereum).

○ There are absolutely no dependencies other than the blockchain to create and view artwork at any time in the future.

○ Level 3 on-chain artworks are all minted fully on-chain and the developers do not have the ability to change the outputs at all at any time during and post-mint.

○ Examples of projects:

- Autoglyph collection from Larva Labs which was created in April 2019
- Brotchain by Divergence
- Shackled from the Spectra team. Ethereum the first general-purpose 3D rendering engine

○ Limitations of this art:

- Prohibitively expensive to store large amounts of data on the blockchain which is why it is typically limited to ASCII art or basic 2D renders

Source:https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts/

Level 2

○ Has only 1 (or 0) dependencies and has been pioneered by the Art Blocks platform started by Snowfro. (Some AB projects are now Level 3)

○ At Level 2, when a piece is minted on-chain the developer has no control over the final output, and the contract and unique identifiers of each individual piece are all stored on the blockchain.

○ The artwork is then generated live on your browser using an API such as p5.js, Processing, or JS Canvas to render interactive 2D and 3D graphics.

○ Examples of projects:
- Ringers from Dmitri Cherniak
- Fidenza from Tyler Hobbs
- Fragments of an Infinite Field by Monica Rizzolli

Source:https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts/
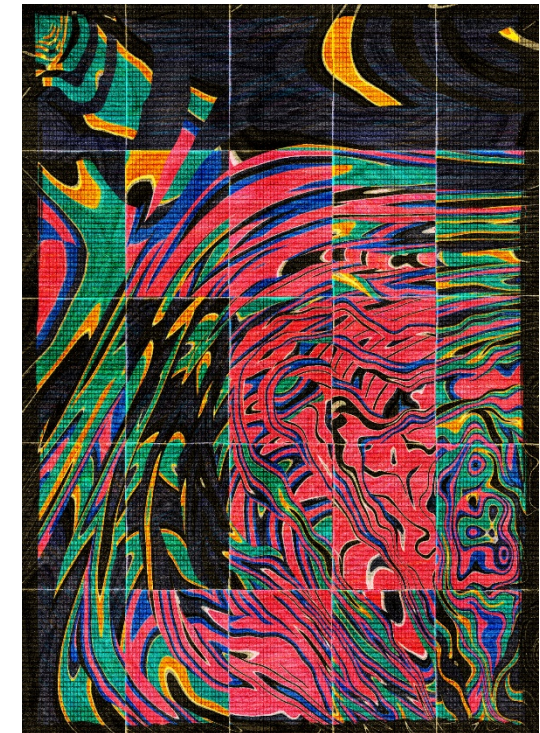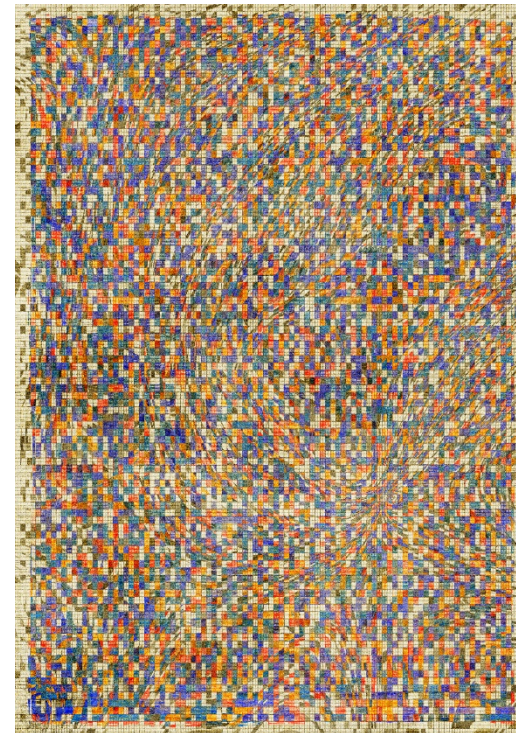
Level 1

○ For Level 1 on-chain generated art, the contracts and unique identifiers are all present and minted live on the blockchain and there is no control or curation available to the artist at the public mint. However, instead of live drawing the artwork using an API, Level 1 projects use the algorithm in the contracts to combine different image layers together to create the final outputs.

○ The images are stored 'off-chain' (typically due to large file size of the image layers) the developer technically has the power to change the pointer to the image files for the collection.

○ Examples of projects:
  • PFP projects like MetaHeroes by Pixel Vault
  • Generative photography project REFLECTIONS by Dream Lab.

Source:https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts/

Level 0

o Art that is curated manually off-chain and the images and metadata are all hosted off-chain. Level 0 is where all photography projects and most PFP projects are. These generative projects combine image layers as well using a generative script, however, the big difference here is that it is all done 'off-chain'.

o The contract is published on-chain so the minting process can be shown to be random, so it's not possible for the team to front-run the other minters by knowing which token ids are rarer (and more valuable) than others.

Examples of projects:

o Bored Ape Yacht Club

o CloneX

o Doodle

Source:https://nftevening.com/own-a-piece-of-history-with-the-beautifully-simplistic-autoglyphs-nfts/
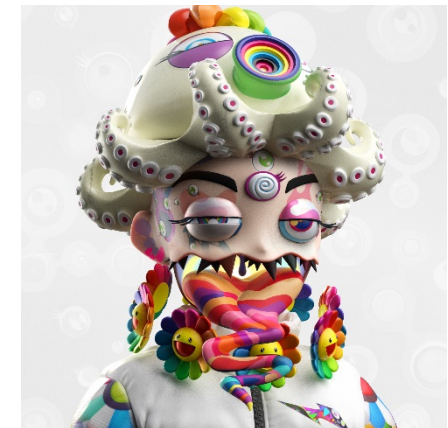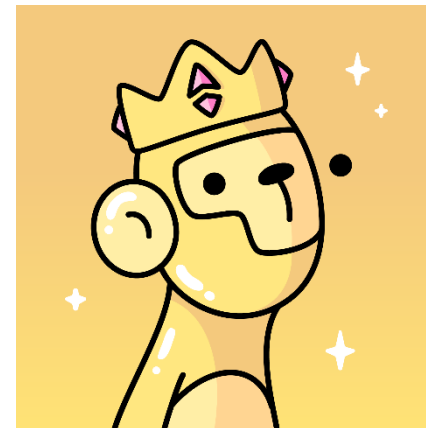
Generative art on the blockchain

o Art blocks is a platform focused on the curation of programmable generative artworks which are stored on the Ethereum blockchain as an NFT and sold

o The works are usually programmed using p5.js, a JavaScript library that allows creative coding, the script is stored on a chain. When new artwork is minted a unique 'seed' is pseudo-randomly generated with the script thus generating a unique artwork on mint. The seed sets the initial variables associated with the script

o Produced on-demand a one-of-a-kind piece in that style

o There are 3 types of art blocks projects:
  • **Curated** - These works are chosen by the Art Blocks team as an exemplification of the high level of creativity and execution possible in crypto art.
  • **Playground** - After an artist has been chosen for a curated collection. Space for experimentation and for artists to explore what's next for their projects.
  • **Factory** - Any artist can submit their pieces to be part of the Factory

Source: https://www.loop-news.com/p/art-blocks-simply-explained
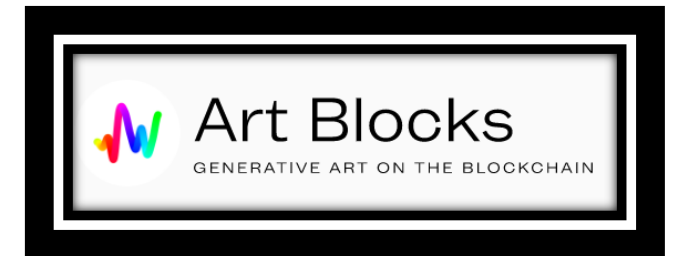
Fx (hash) / Feral File

fx(hash) fxhash is an open platform to **create** and **collect** generative NFTs on the tezos blockchain
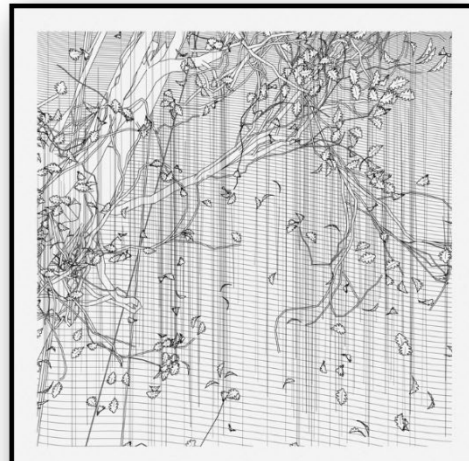
FERAL FILE

commissions curated exhibitions

20 OCTOBER 2022 - 15:00:00

Simulation Sketchbook: Works in Process

Curator
Jesse Damiani

Featured Artists
Alida Sun, Anne Spalter, Botto, Behnaz Farahi, David OReilly, IX Shells, John Gerrard, Mimi Onuoha, Monica Rizzolli, Qianqian Ye, Reeps One

Garden, Monoliths
zancan ✓
255/255 minted ✓

A Bugged Forest
zancan ✓
1000/1000 minted ✓

Source: https://www.fxhash.xyz/explore

Non-Fungible Tokens (NFTs) and the Metaverse
Session 5: Art NFTs (Generative Art)

Pushing the boundaries of on-chain Generative art: Deafbeef

0xDEAFBEEF
@_deafbeef

o Generative audiovisual fully on-chain art.

o Self-contained C code.

o Series 0 - Synth Poems are short generative music pieces, inspired by the sound of analog synthesizers. Each piece is generated at the time of minting from a random hash value.

o Although synth poems are audio focused, a fitting visualization is added as an ode to early computer graphics that used vector displays to visualize analog signals. What you see is a direct representation of the sound signal, as it would appear on an oscilloscope.

DEAFBEEF Series 2: Transmission – Token 139

Source: https://jpg.mirror.xyz/qSUps1Krz02iyW8FCWHiEcHGaLrslw6BSldJQpuD9_A

Refik Anadol
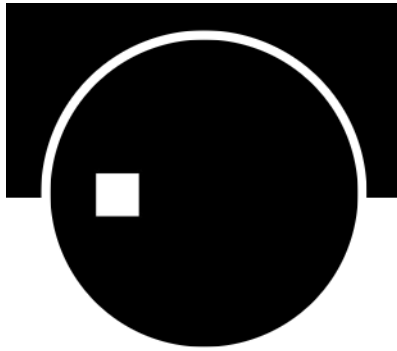
Refik Anadol ✔
@refikanadol

Embedding media arts into architecture with data and machine intelligence for public art, data sculpture and paintings. Director at RAS.

Source: https://refikanadol.com/about/

Refik Anadol

Refik Anadol ✔
@refikanadol

Embedding media arts into architecture with data and machine intelligence for public art, data sculpture and paintings. Director at RAS.

Source: https://refikanadol.com/about/
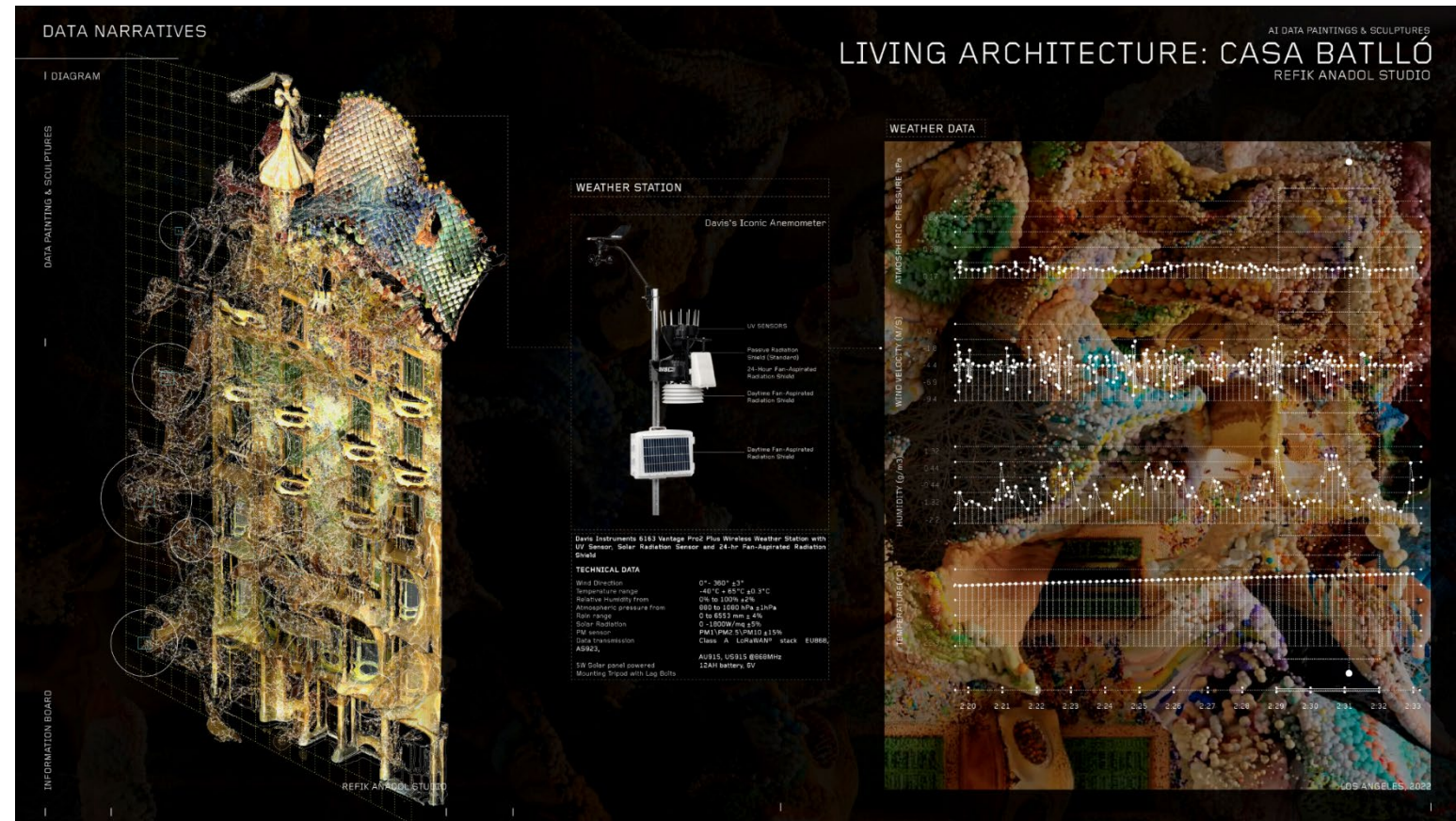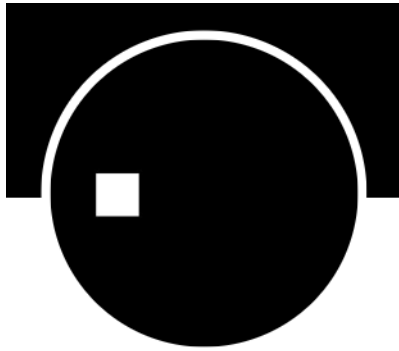
Session 5: Art NFTs (Generative Art)

5. Long-form Generative Art

No curators

o Coding is thus playing an extraordinary role in our contemporary world. There is no better artistic expression than long-form generative art to capture its nature.

o The leading platforms providing the infrastructure for long-form generative art are Art Blocks and Gen.art. Tyler Hobbs, Matt DesLauriers, Kjetil Golid , William Mapan and Dmitri Cherniak are some of the most important artists who have burst onto the scene. Their works play with lines, colours, textures, thickness, movements and the like. Each result is hugely evocative, eliciting a range of feelings in the viewer.
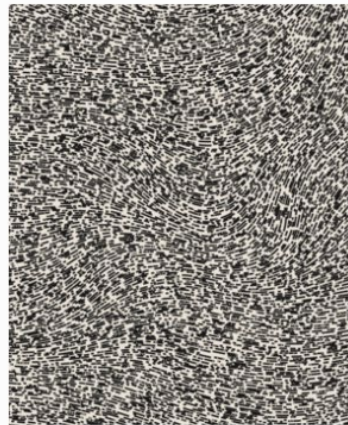
Fidenza #222   Fidenza #479   Fidenza #430

Sources: 1. A Whirlwind History of Generative Art: from Molnár to Hobbs; 2. The Rise of Long-Form Generative Art

Tyler Hobbs

Tyler Hobbs
@tylerxhobbs
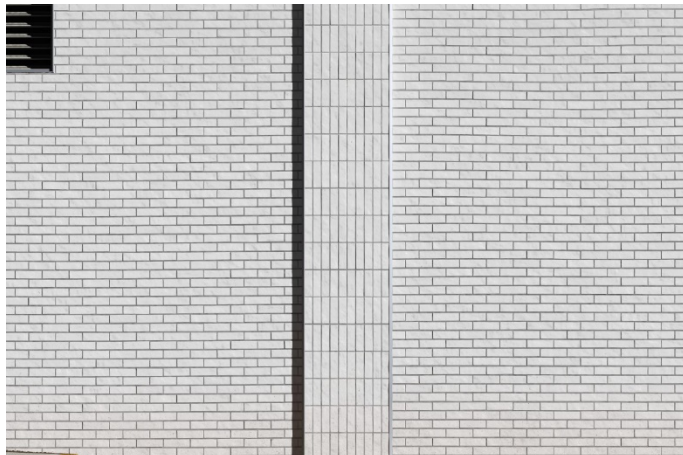
WALL [2022] *(short form)*

Fidenza [2021]
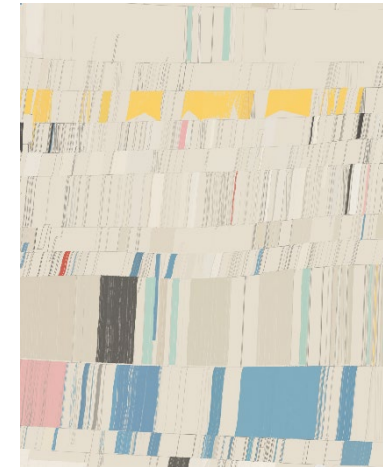
Incomplete Control
[2021]

ANTICLASSIC [2021]
(short form)

Non-Fungible Tokens (NFTs) and the Metaverse
Session 5: Art NFTs (Generative Art)

Dmitri Cherniak
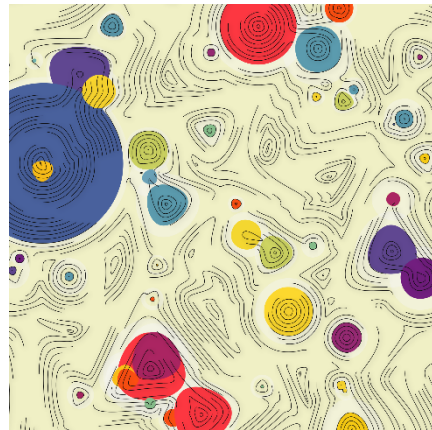
Self portrait #1 [2020]
(short form)
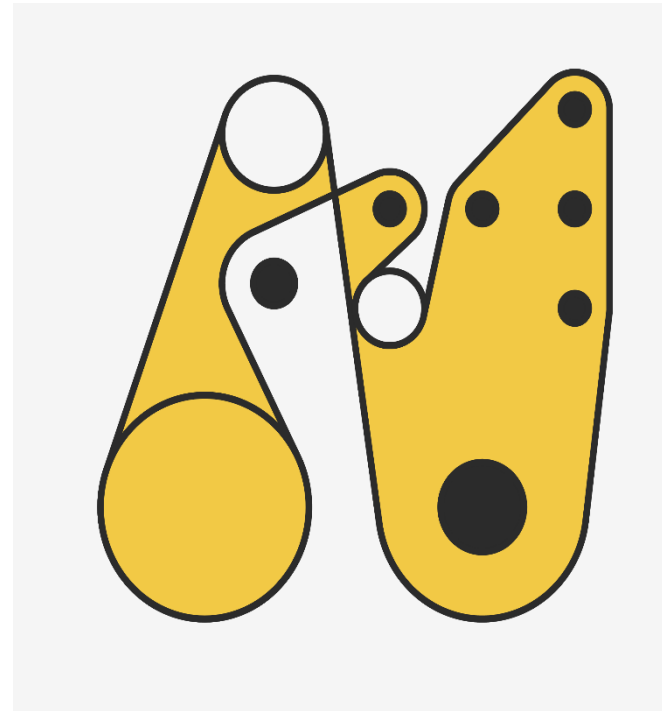
Ringers [2021]
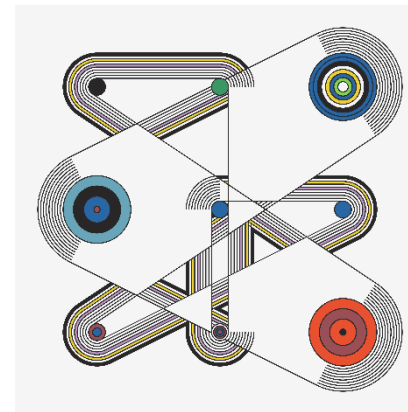
A slight lack of
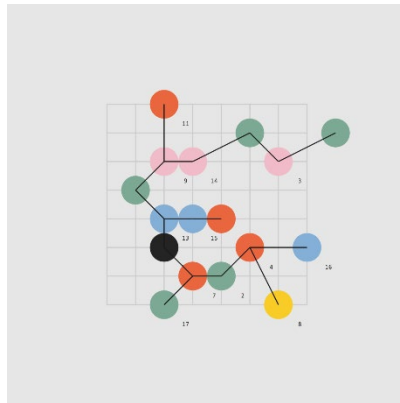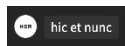symmetry can cause
so much pain [2021]
(short form)

The Eternal Pump
[2021]

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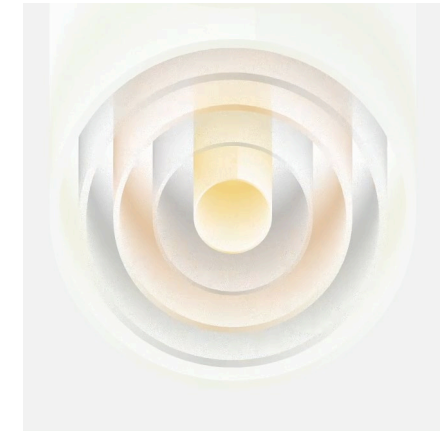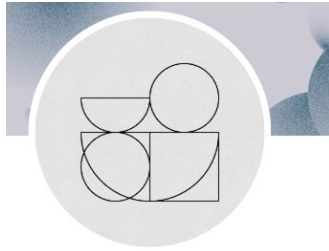
Matt DesLauriers

Matt DesLauriers
@mattdesl

spanning tree sketch 01
[2021]

Meridians [2021]
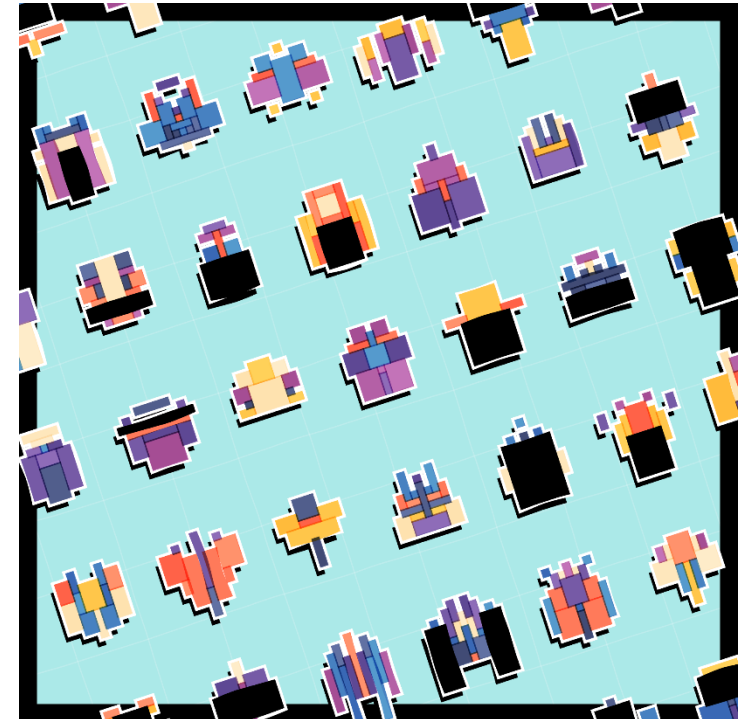

FOLIO [2022]
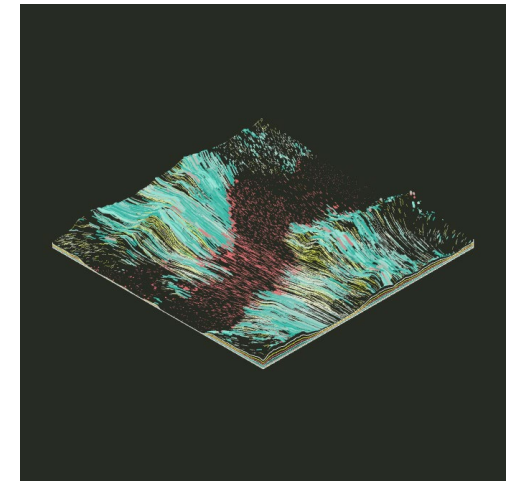
Subscapes [2021]

Kjetil Golid

Kjetil Golid
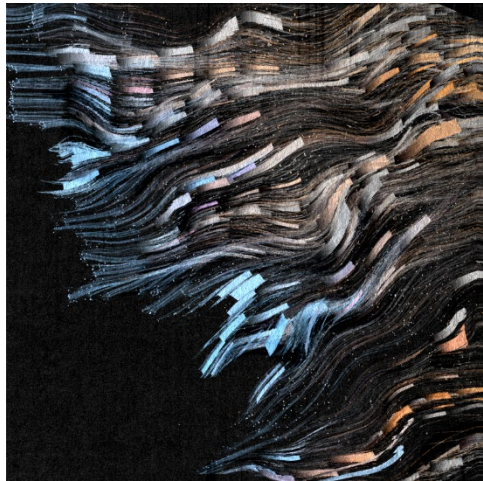@kGolid

Rejoice [2021]
(short form)
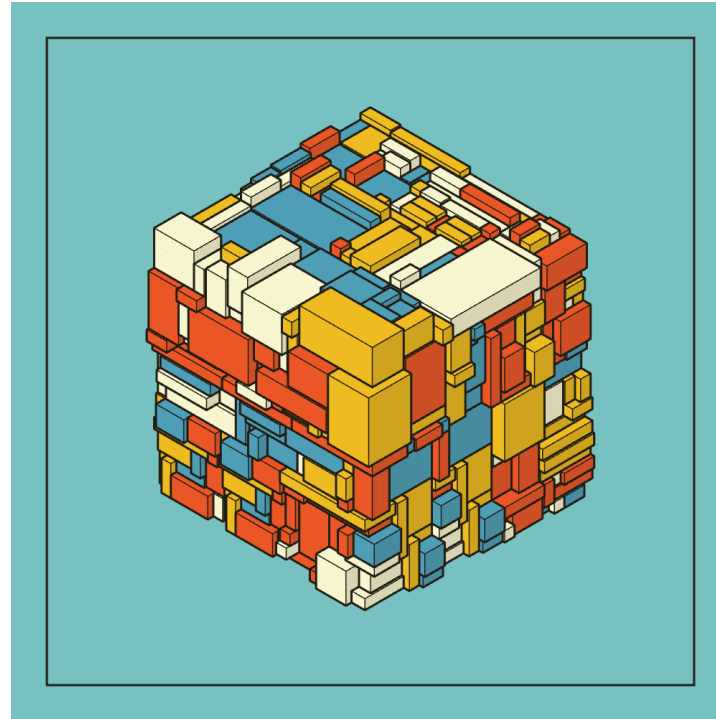
Archetype [2021]

Paper Armada [2021]

Non-Fungible Tokens (NFTs) and the Metaverse
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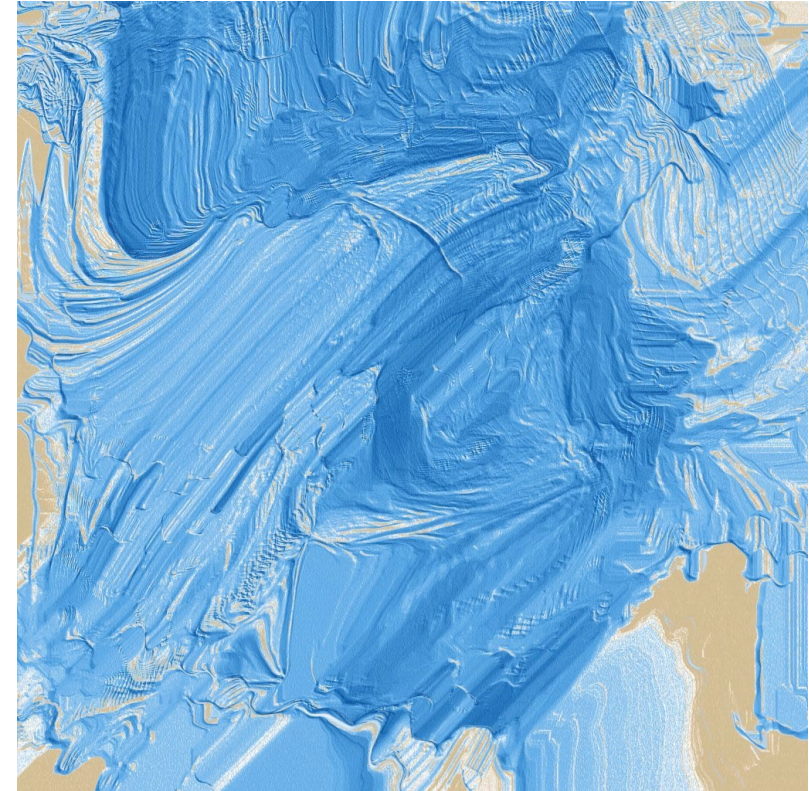# William Mapan

William Mapan
@williamapan

Dragons [2022] *fx(hash)*
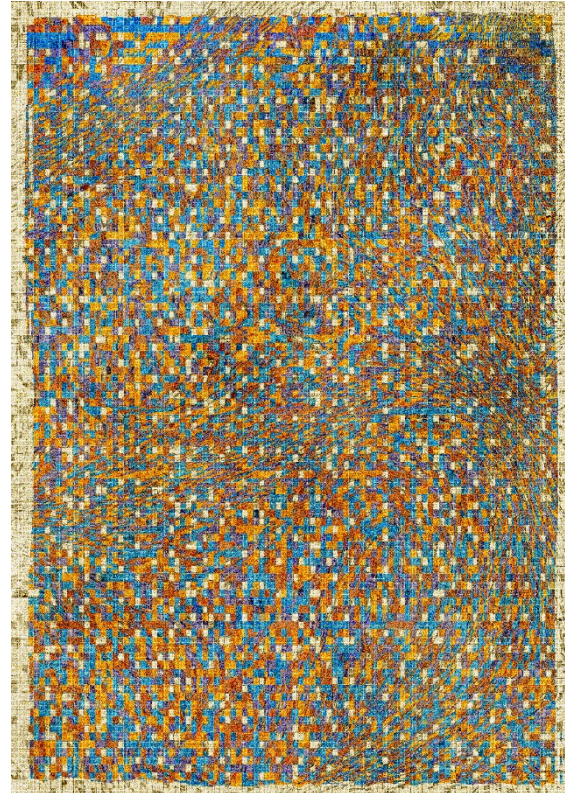
Anticyclone [2022]

Algorithmic painting: genesis [2022]
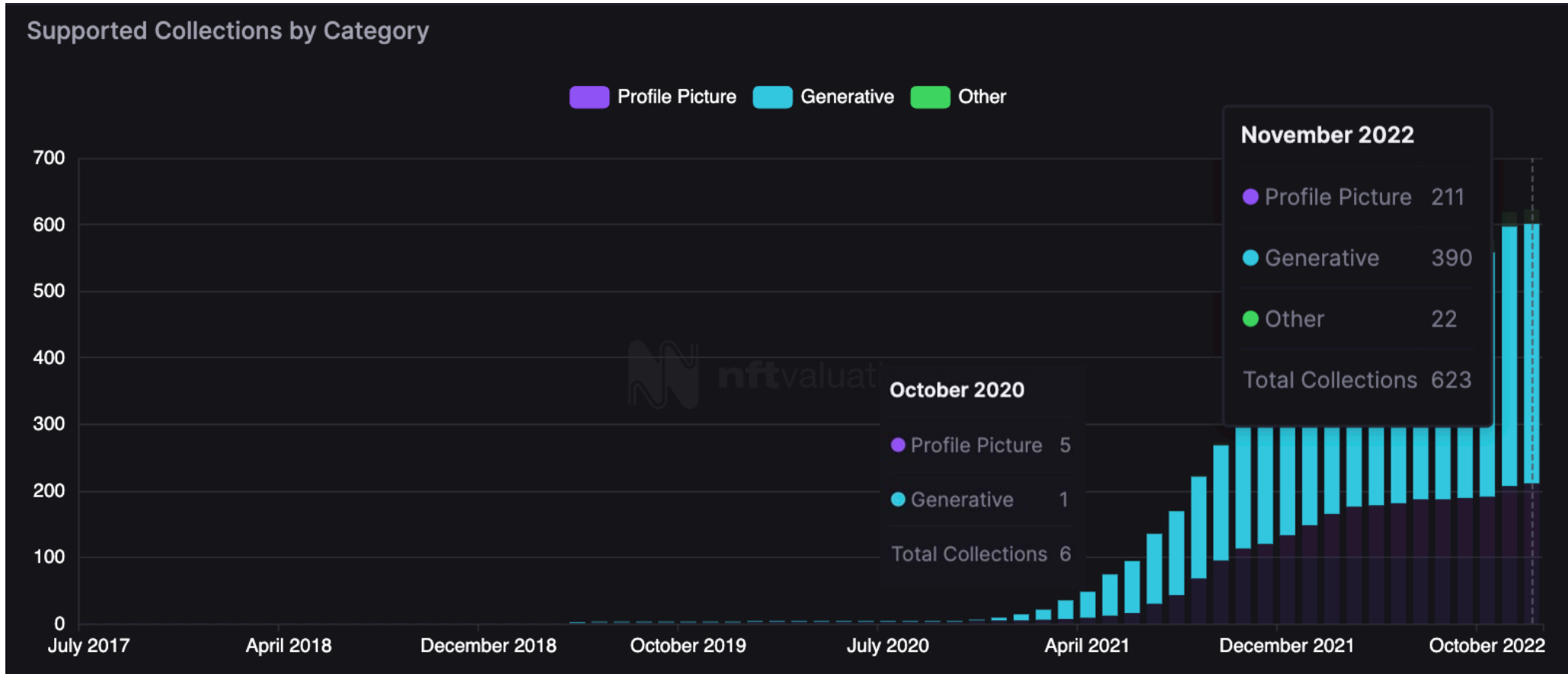
Insights by Tyler Hobbs

Tyler Hobbs

"In summary, long-form generative art introduces the new demands of consistent quality and high variety, while maintaining the existing need for unity across all output from a program. Right now, few artists are capable of navigating this balance, but I have no doubt that will change. The art form is just ramping up, and generative artists are starting to become familiar with the new dynamic. Short-form generative work will continue to exist and will continue to be the best fit for many artistic visions, but right now long-form is the fertile, unexplored space. I look forward to seeing all of the amazing work that will be created over the next few years!"

Source: https://tylerxhobbs.com/essays/2021/the-rise-of-long-form-generative-art

Session 5: Art NFTs (Generative Art)

6. Market

Number of collections

Number of collections

Market

Self Portrait #1
dmitricherniak
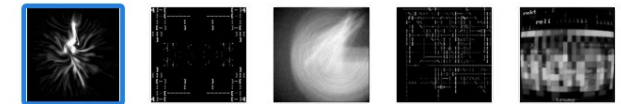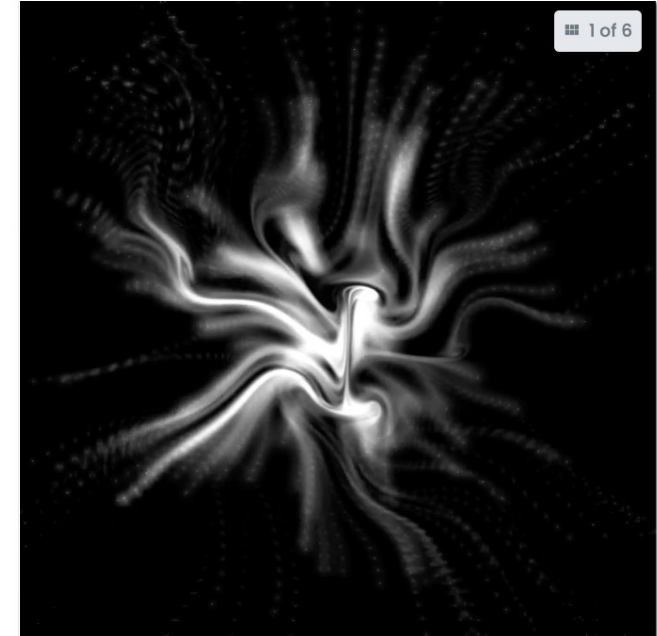$2,682,000.00 (1,727.592 ETH)

Fidenza #313
Tyler Hobbs
$3,322,710 (1000 ETH)

1 of 6

Series 0-6 Full set
Deafbeef
$6,855,758 (2275 ETH)

Non-Fungible Tokens (NFTs) and the Metaverse
Session 5: Art NFTs (Generative Art)

Session 5: Art NFTs (Generative Art)

7. Conclusions and Further Reading

Takeaways from week 5

o Generative art is a long-standing art movement that incorporates automation in the creation of art works

o The provenance features that blockchains can provide appear to be an interesting fit with the procedural features of generative art

o The large majority of NFTs are generative in some capacity -> from simple generative PFP collections to highly complex fine art generative art work

o There are significant differences in how "on-chain" various generative art projects, but, in general, generative art is quite well suited to be stored on-chain, given its algorithmic nature

o Long-form generative art is an approach that was quite difficult to do pre-NFTs. In this approach the algorithm is known before mint but the outputs are not and the net result is a "1 / 1 of X" collection with various outputs of the same algorithm, each previously unknown to the artist and collector

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Further Reading

o <u>Was Da Vinci a model for Mona Lisa?</u> : Art analysis by Lillian F. Schwartz:

o <u>Generative art Guide:</u> Examples, Software and Tools to Make Algorithm Art

o <u>The importance of generative art:</u> A Tyler Hobbs essay

o <u>Why love generative art?:</u> An article by Jason Bailey, at Artnome.com discussing generative art

o <u>Using Python to Make Art With Math:</u> An article showing how Python and Math could be used to create generative art

o <u>What are Generative Art NFTs?:</u> An article by CoinDesk explaining generative art NFTs and refer to software used to create generative art NFTs

o <u>The rise of long-form generative art:</u> An essay by Tyler Hobbs discussing the early days of generative art and its future

o <u>Fidenza</u>: An article explaining Fidneza's generative algorithm developed by Tyler Hobbs

o <u>Types of Generative Projects on ArtBlocks:</u> An article by Art Blocks Editorial presenting the different types of projects on Art Blocks platform.

Tip: Clicking while pressing Cltl key opens a new tab in Chrome browser on non-Apple devices

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