

GANs with Python

Setup

Note: This workshop requires an understanding of basic Python. Experience from your own projects is fine.

1. Go to this link: linktr.ee/dolica.ual
2. Open the GANs with Python Notebook link.
3. Log in to your Google account.

What are GANs?

- GAN stands for Generative Adversarial Networks.
- They have exploded in popularity in quite a short time.
- It started in a pub...

So what does Generative Adversarial Network? Well let's start with the word *generative*...

Generative?

Generative: Capable of producing or creating something.

- **Discriminative:** Identifies and distinguishes between categories, such as recognising that a cat is a cat and a dog is a dog.
- **Generative:** Generates new instances of cats or dogs by applying learned patterns.

Later, we'll explore how GANs actually combine these things.



Adversarial?

Adversarial: involving people opposing or disagreeing with each other.





Network?

Neural networks are algorithms that endeavor to recognise the underlying relationships in a set of data.

Putting it all together...

We are *generating* fake data by using two neural *networks* that have an *adversarial* relationship.

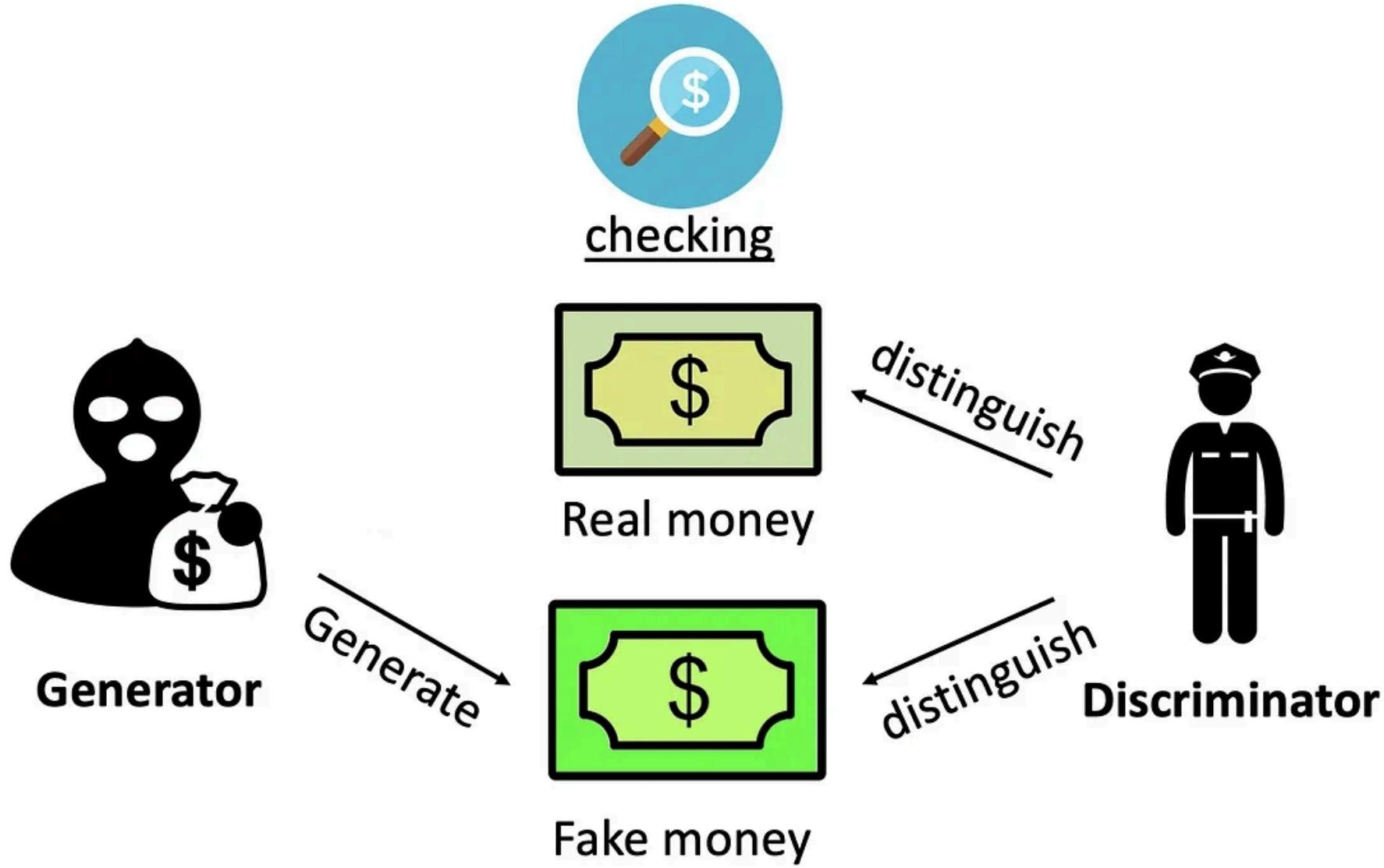
GAN Components

- A **Generator** ("the criminal") is trying to learn to create fake images
- A **Discriminator** ("the detective") is trying to tell real images from the fake images
- The two neural networks are *trained* simultaneously

We can think of a GAN as being like a turn-based game...

The GAN Game I

1. Our criminal creates a fake note
2. Our detective sees a real note and a fake note and is asked to tell which is which
3. The criminal "wins" a round of the game if it fools the detective
4. The detective "wins" a round of the game if it can spot the fake
5. The loser then goes away and changes their *strategy* in the next round of the game
but the winner simply carries on what it was doing before



The GAN Game II

- The game takes place for several turns (or epochs) (or iterations...)
 - For us this can mean leaving the code running for several hours...
- We want our detective to get smarter, because that means the criminal has more of a challenge and is forced to *get better* at creating fake notes
- Ideally, what will happen is that the criminal's fake notes become so convincing that the detective can't tell the difference

Types of GANs

CycleGAN



The background is changed too.

StyleGAN - This Person Does Not Exist



Created using the StyleGAN developed by Nvidia.

StyleGAN - This Person Should Not Exist ??? 🤖



BigGAN



So how does a program store an image?

Lists Recap

In the previous workshop we covered Lists in Python. Lists are an ordered data structure that allow us to hold a collection of items.

```
my_list = [1, 2, 3, 4, 5]
my_other_list = ["a", "b", "c"]
my_empty_list = []
```

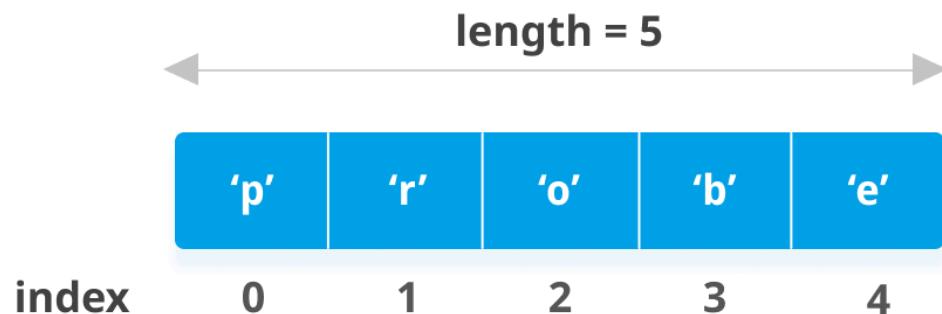
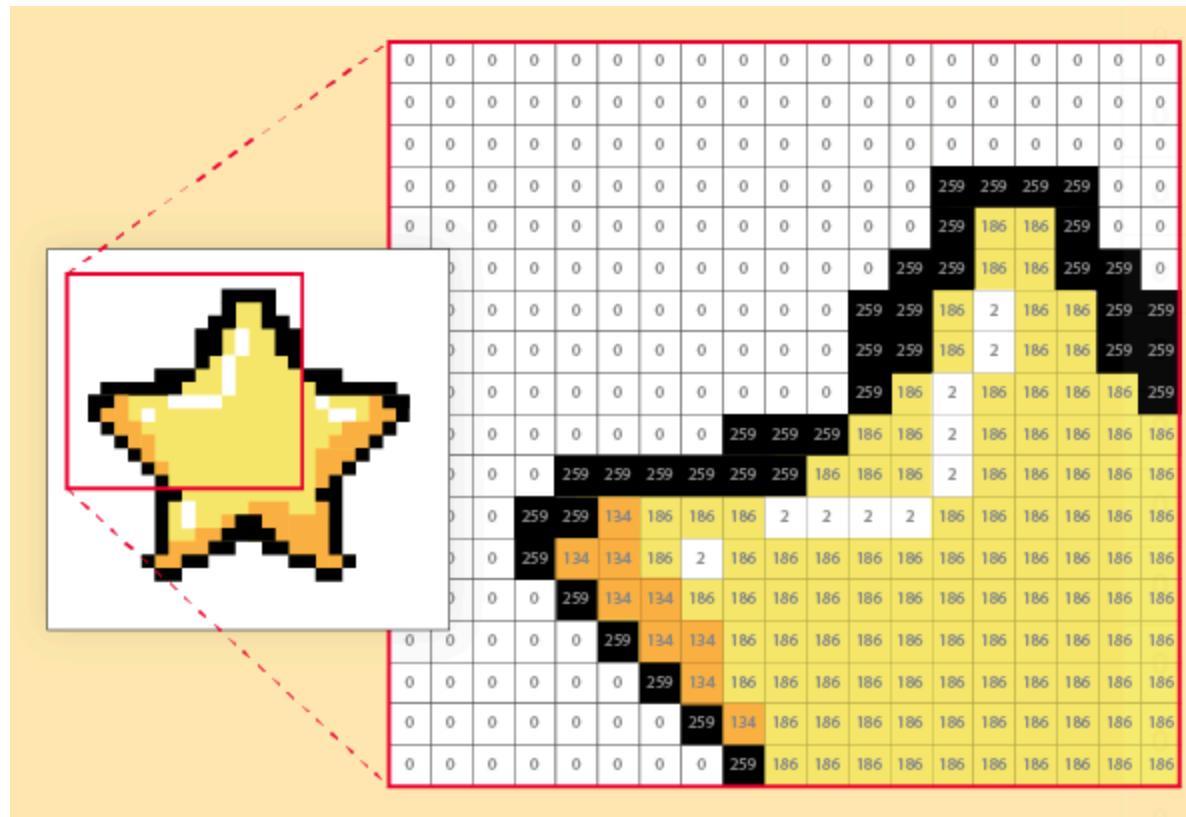


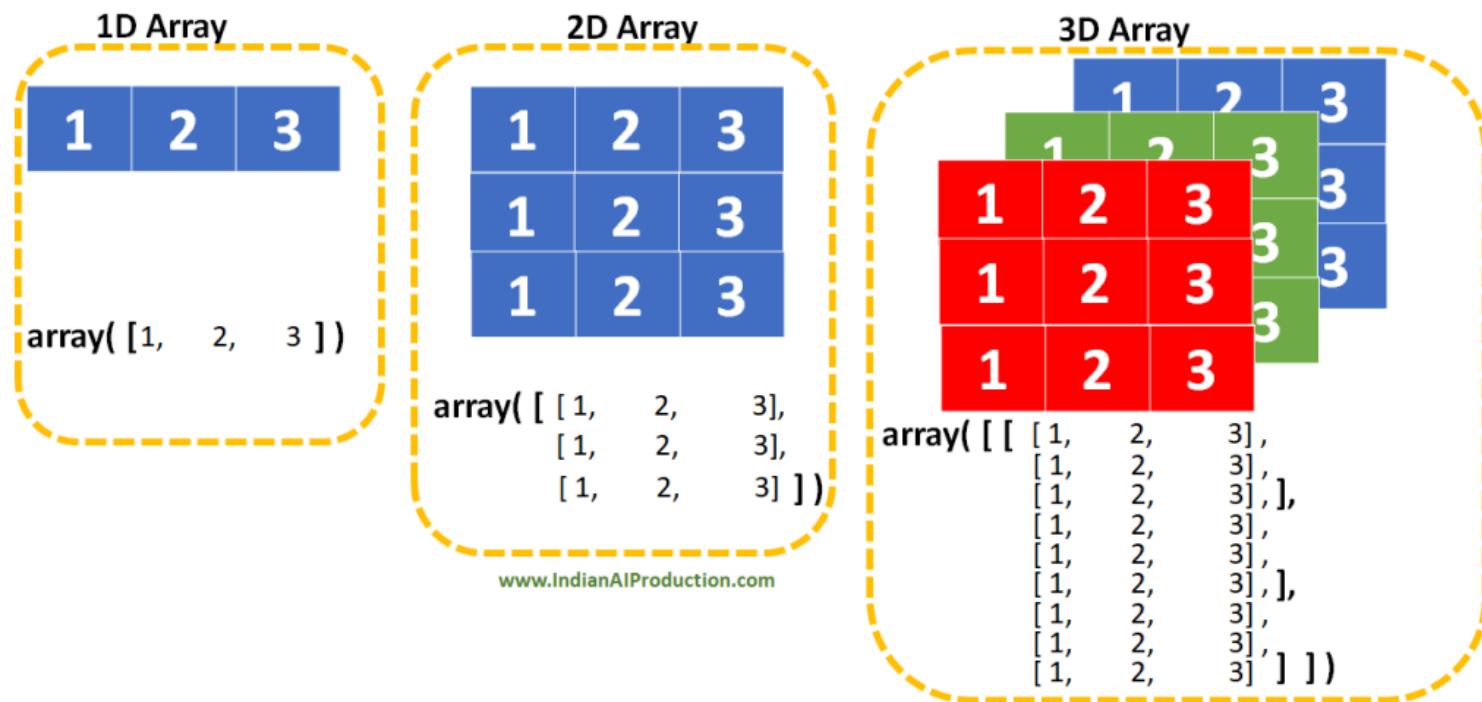
Image Data

So for images we ought to use something like a list for holding values for our pixels, but with something a bit more...



Arrays and Images

In the code we will store our images in the form of something called *arrays*. Like Lists, they are able to hold a collection of values and store them in a single variable. But because we are dealing with images we need a "grid" (or more accurately several grids) rather than a simple list.

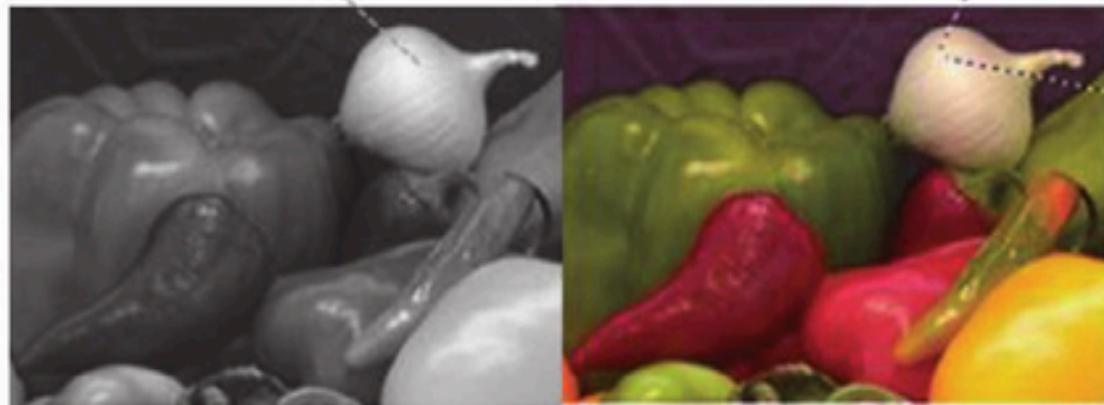


Arrays and Images

- Black and White images: 2D array for "brightness"
- Colour images: 3D array for RGB channels

The GAN has *less work to do* in the case of black and white images.

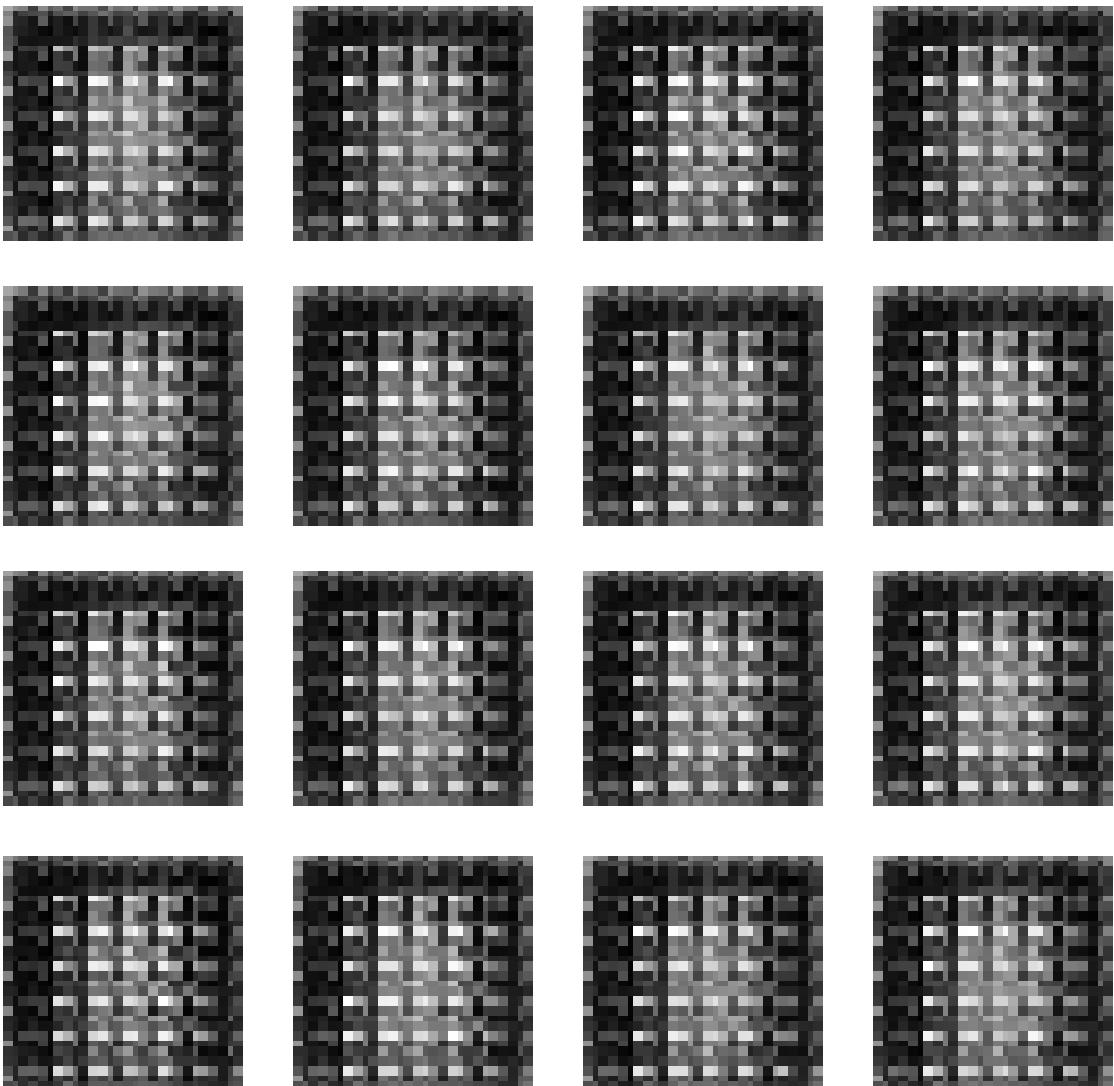
		Intensity value at Pixel location $f(2,2)$		
		Columns		
R	o	(120 145 150 135 140 160 125 135 165)	w	s



BLUE		
210	214	216
208	210	211
204	2	
GREEN		
167	188	188
186	185	194
183	18	
RED		
236	238	239
235	234	234
230	206	232

MNIST Dataset

- MNIST is a well-known dataset of handwritten numbers
- Very popular for testing image processing code

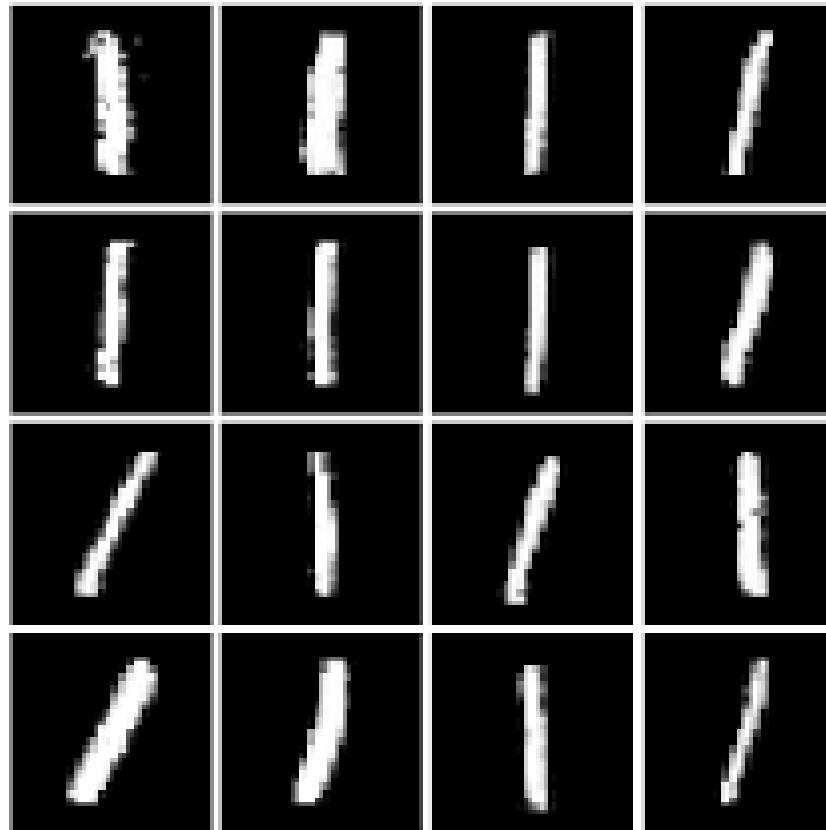


Basic Classification Example

<https://www.3blue1brown.com/lessons/neural-networks>

Issues with GANs

Mode Collapse



These are definitely ones...

Generated Images



Convergence Failure

Convergence failure is what happens when the generator and discriminator do not reach balance during training.

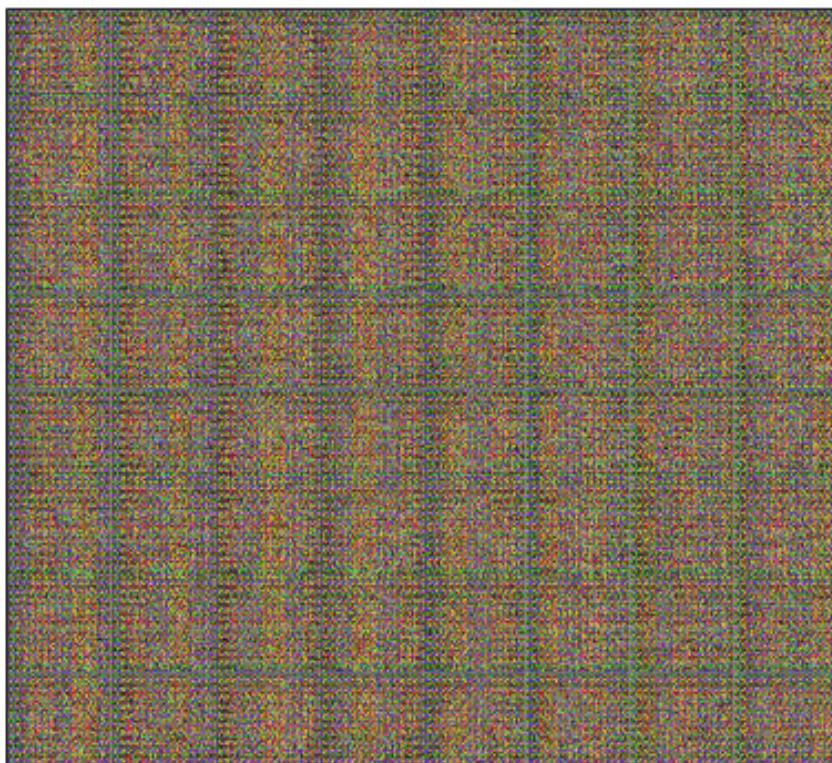
Discriminator Dominates

The detective becomes too smart too early in the game, so the criminal doesn't get a chance to properly learn what it should and shouldn't do to create convincing notes.

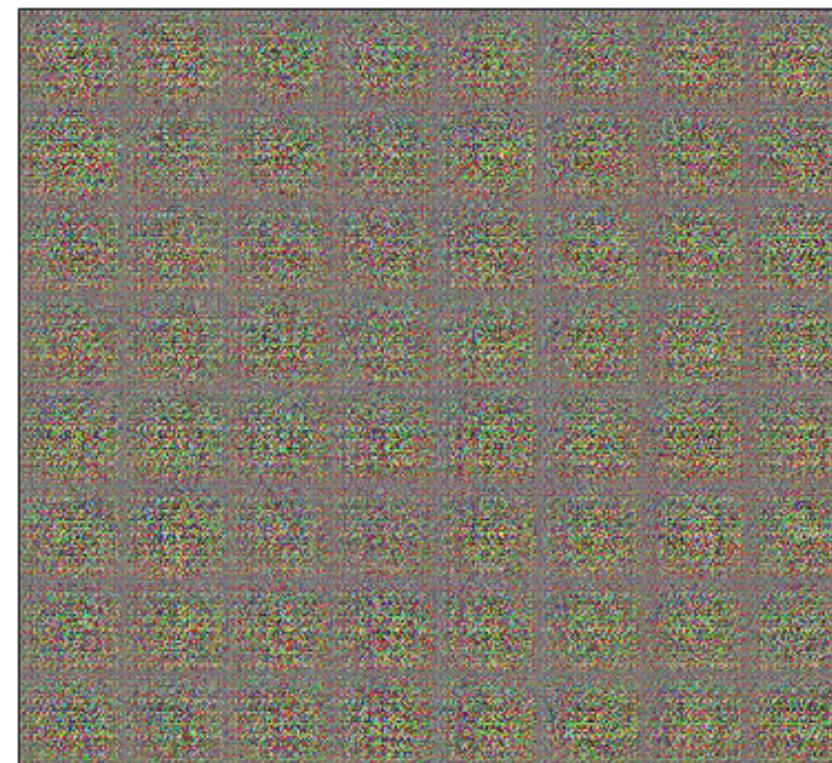
Generator Dominates

The criminal gets too smart too early in the game, so it's able to get away with making "meh" notes as these are still enough to fool the detective.

Generated Images



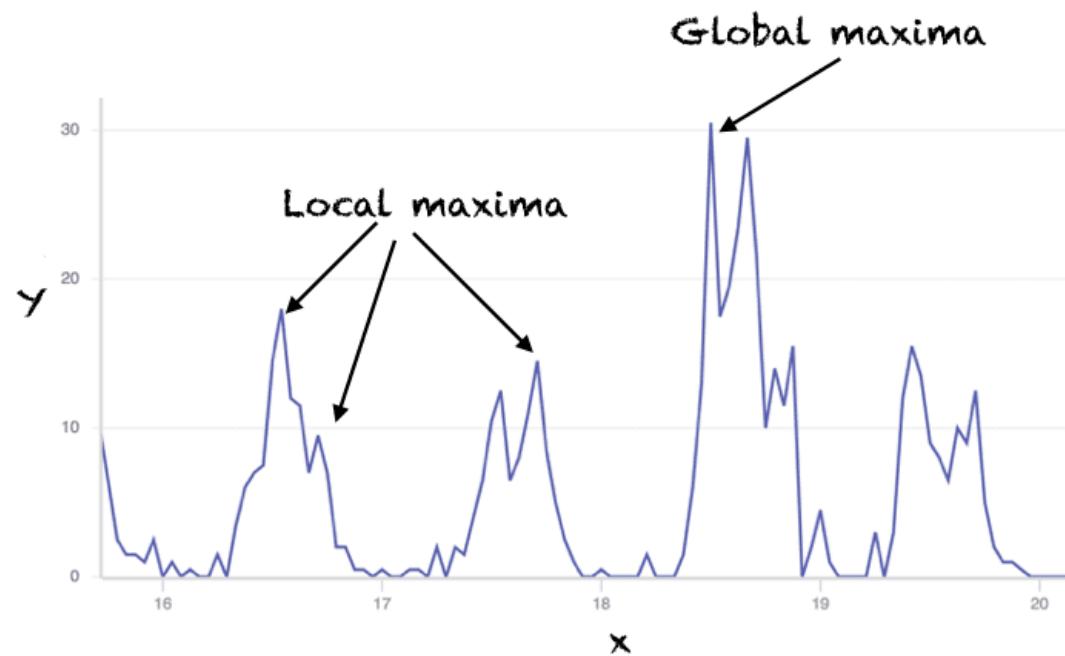
Generated Images



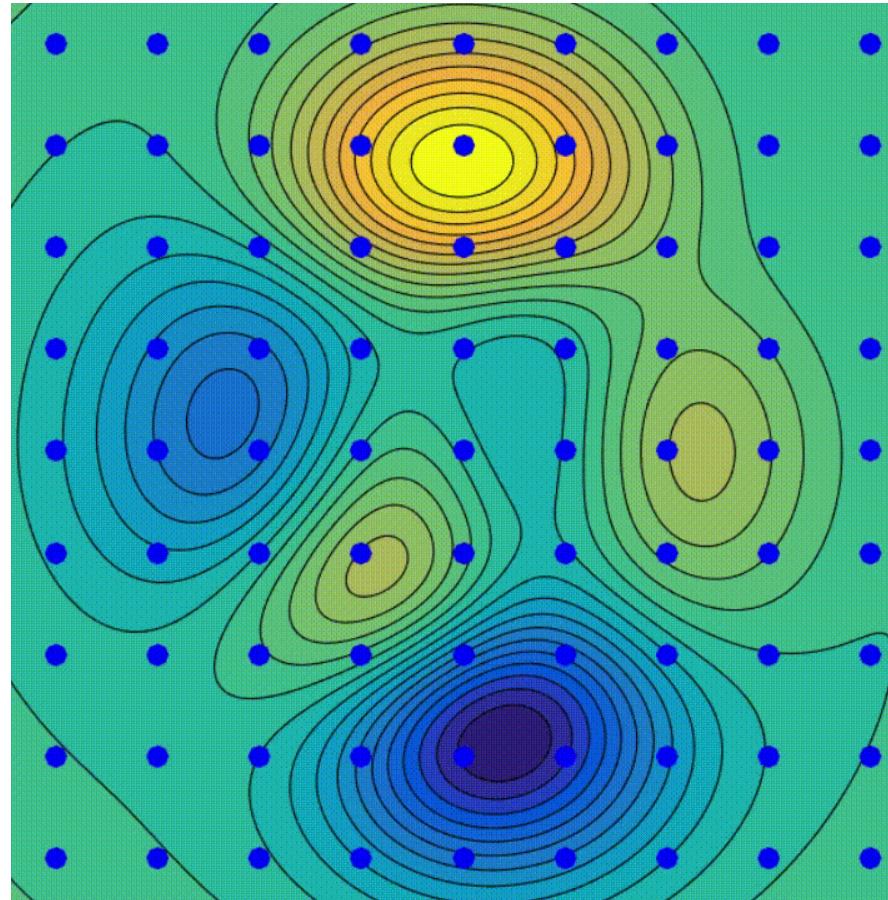
How do we know that our GAN is heading in a good direction?

Mathematical Optimisation (or Min-Max Problems)

GANs are based on the maths of optimisation. The objective of optimisation is to find the best solution to problem.



Gradient Descent



So what do we wish to "optimise" when running our GAN?

Loss Functions

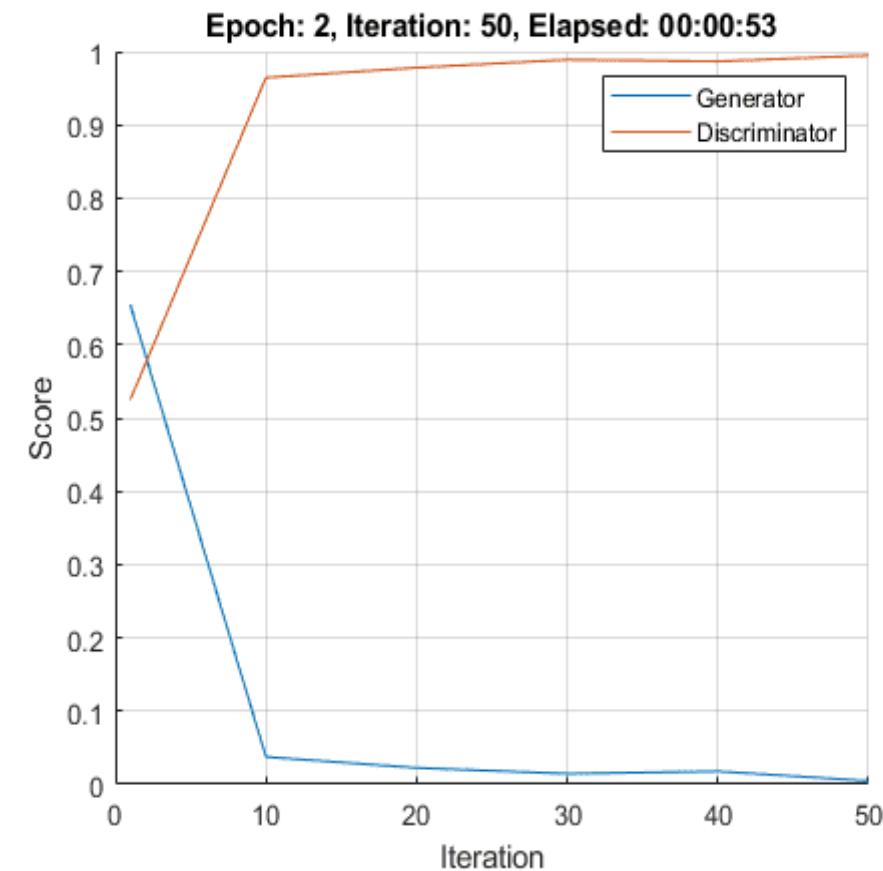
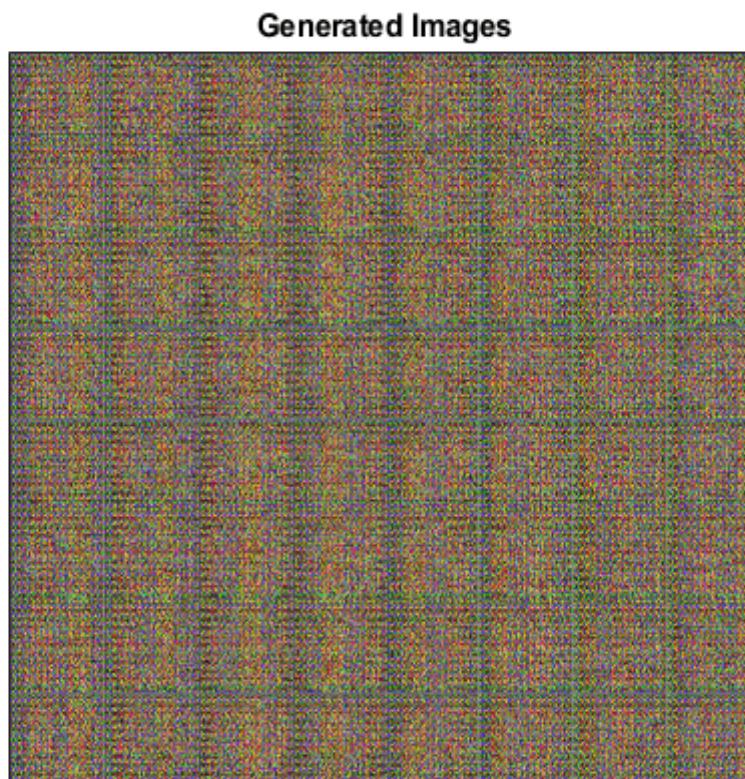
Our loss functions give us an indication of how well the Generator and Discriminator are performing.

- x is a real image.
- $D(x)$ is the Discriminator's judgement on the real image.
- z is random noise.
- $G(z)$ is the Generator's attempt at creating a fake image.
- $D(G(z))$ is the Discriminator's judgement on the fake image.

The Discriminator wants $D(x)$ to be high as possible. For $D(G(z))$ the Discriminator wants this to be as low as possible while the Generator wants this to be as high as possible.

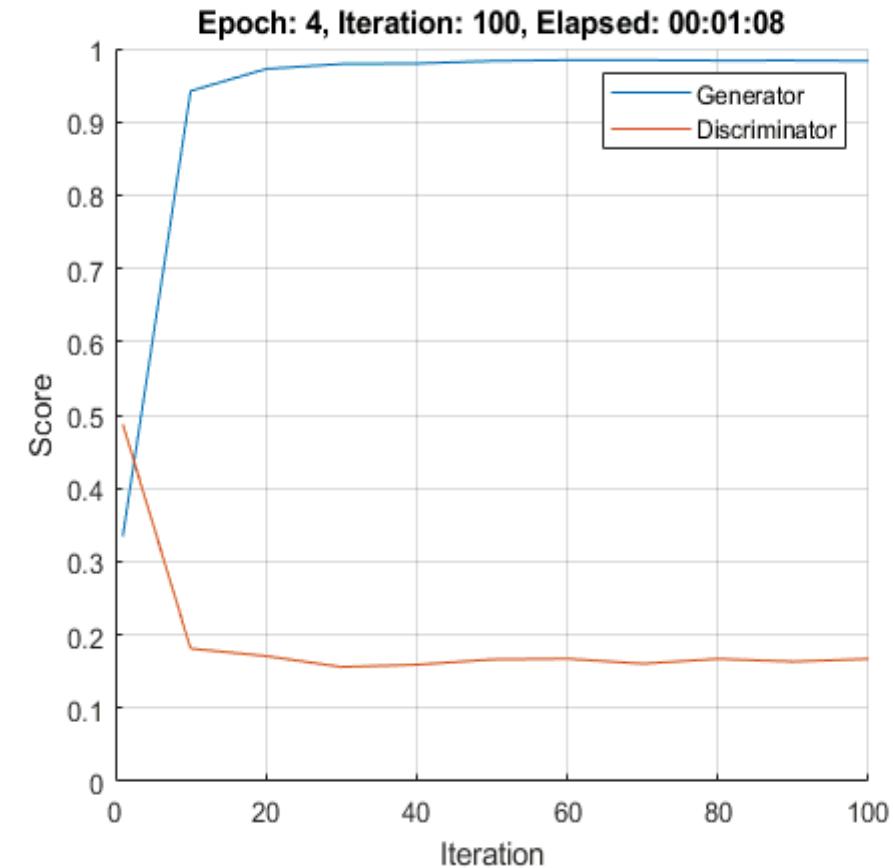
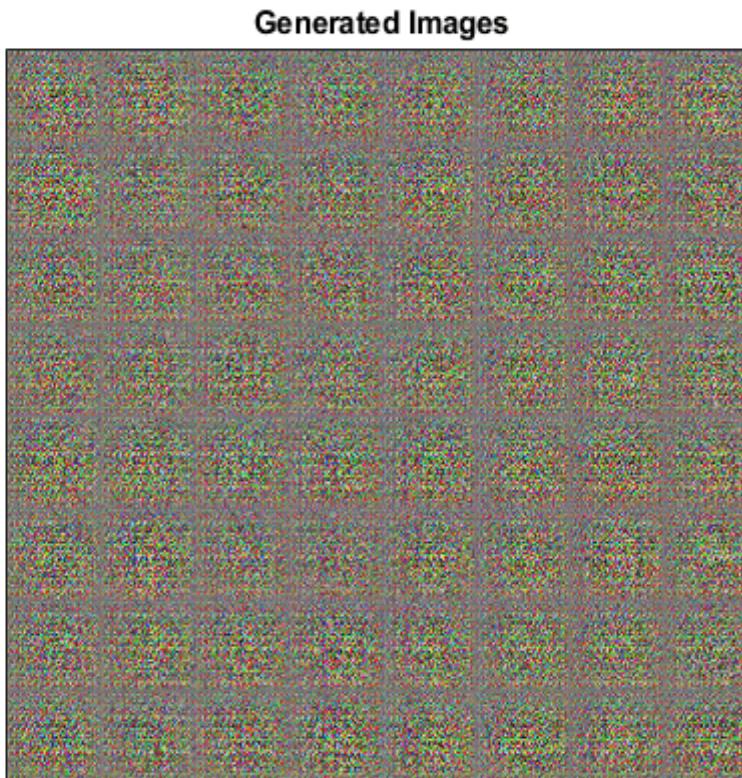
Convergence Failure

Discriminator Dominates



Convergence Failure

Generator Dominates



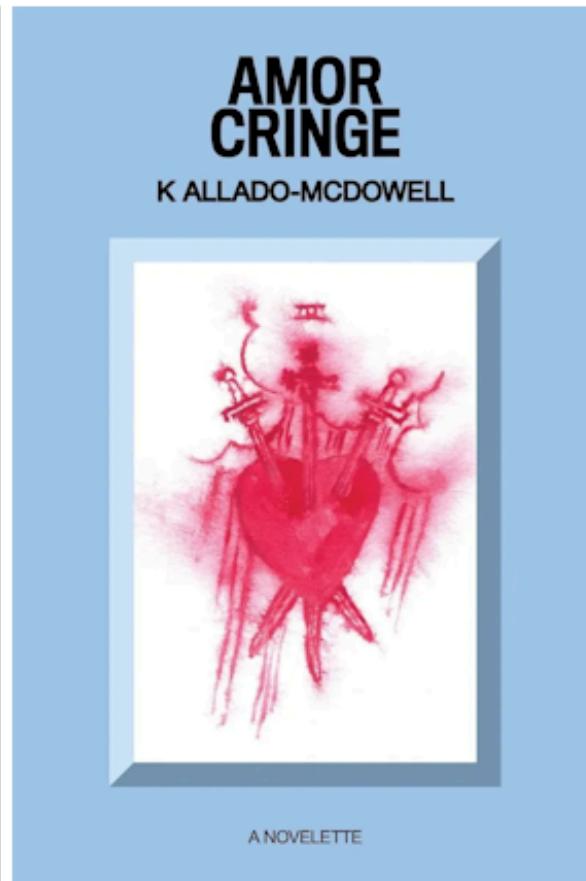
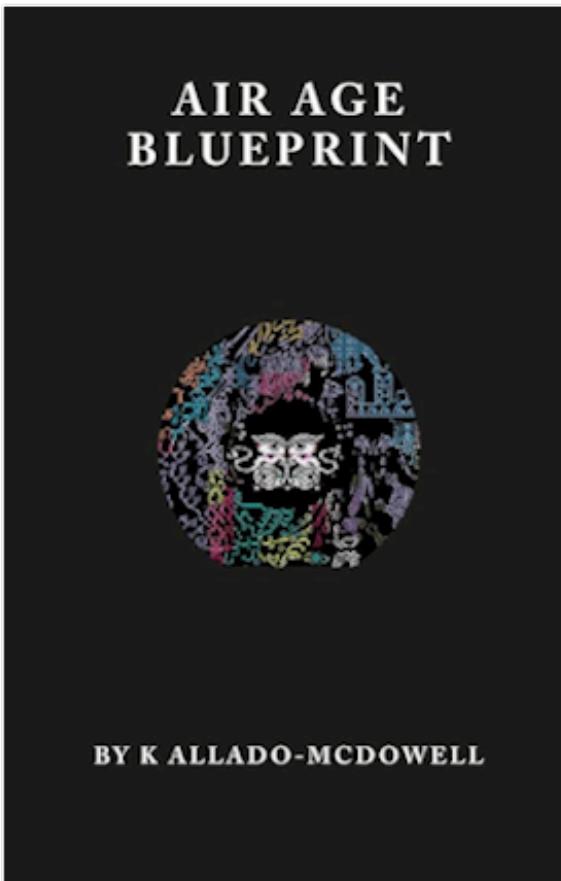
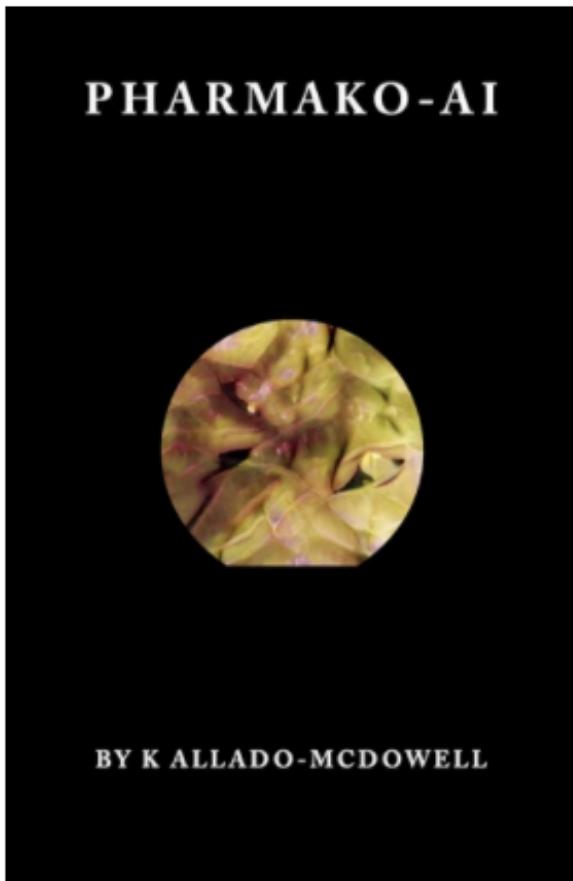
Now let's head over to the notebook...

Creative AI Stuff

Artist + Machine Intelligence

<https://ami.withgoogle.com/>

K Allado-McDowell



Google DeepDream

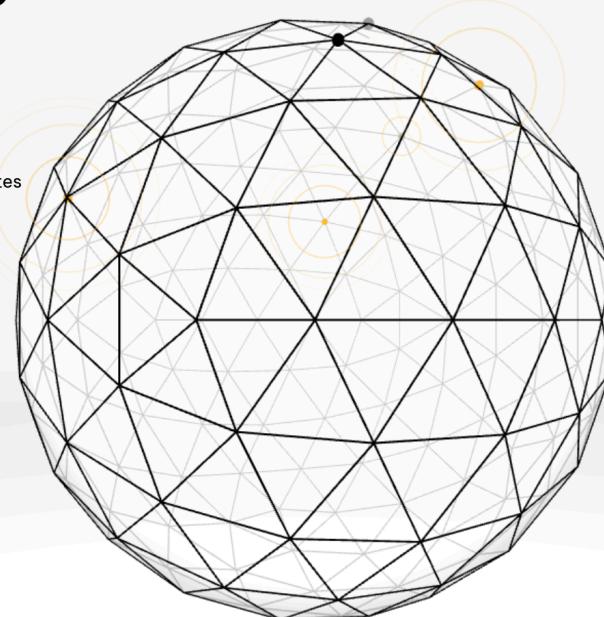


Sound of the Earth

SOUND OF THE EARTH: CHAPTER 3

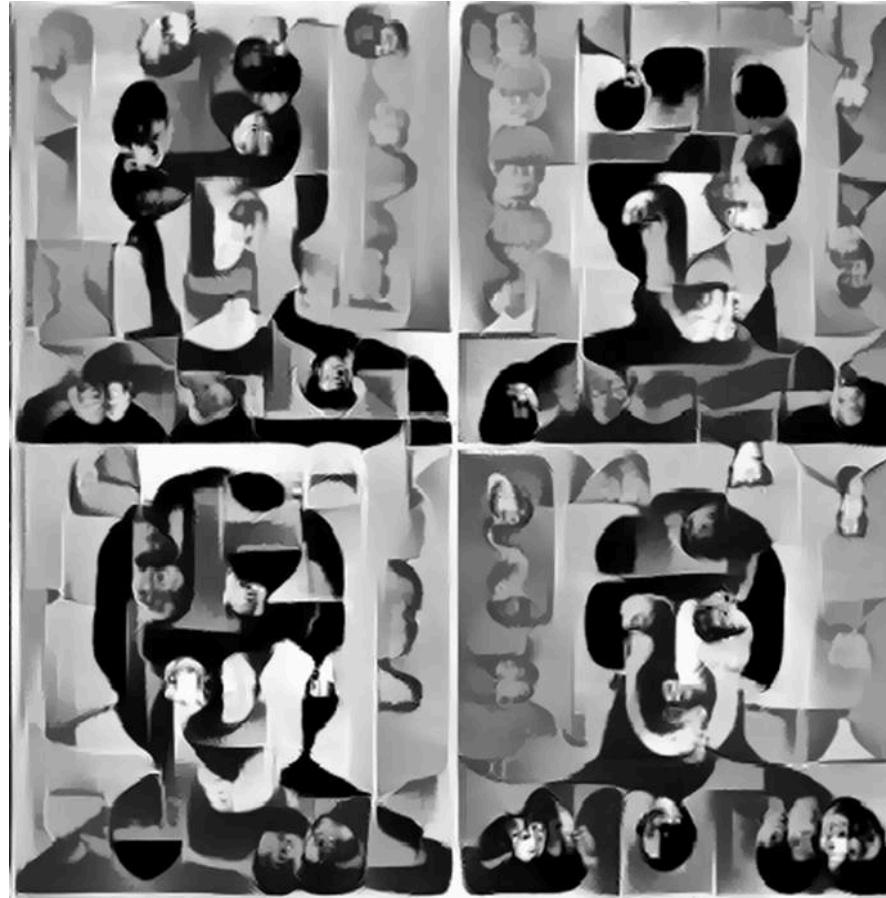
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30-07-2022 15:56:56.29 GMT+0100 Italy
19-10-2022 09:19:10.99 GMT+0100 Netherlands
30-06-2022 05:39:57.42 GMT+0100 Japan
22-08-2022 10:33:25.09 GMT+0100 United Arab Emirates
25-08-2022 02:36:27.82 GMT+0100 United States
26-08-2022 02:36:27.82 GMT+0100 United States



<https://soundoftheearth.org/>

Dadabots



<https://dadabots.bandcamp.com/album/deep-the-beatles>

Ganrio



<https://amyelizabethsmith01.medium.com/gans-sanrio-ganrio-21e263666929>

Wordcar



<https://www.youtube.com/watch?v=TqsW0PMd8R0>

Black To Comm



<https://blacktocomm.bandcamp.com/album/le-jazz-homme>

clowncore (Extremely NSFW...)



There is a link in the Linktree if you're curious about this. The weird stuff starts at 22.30!

"You can think of generative models as giving artificial intelligence a form of imagination." - Ian Goodfellow

Feedback Form

linktr.ee/dolica.ual