14th SYMPOSIUM OF BIAL FOUNDATION
BEHIND AND BEYOND THE BRAIN

Artificial Creativity and Art

Penousal Machado
University of Coimbra
machado@dei.uc.pt

Tiago Martins
University of Coimbra
tiagofm@dei.uc.pt

April 5, 2024

1290 UNIVERSIDADE D COIMBRA
dei departamento de engenharia informática
LASI Intelligent Systems Associate Laboratory
CISUC COGNITIVE AND MEDIA SYSTEMS
COMPUTATIONAL DESIGN & VISUALIZATION LAB.

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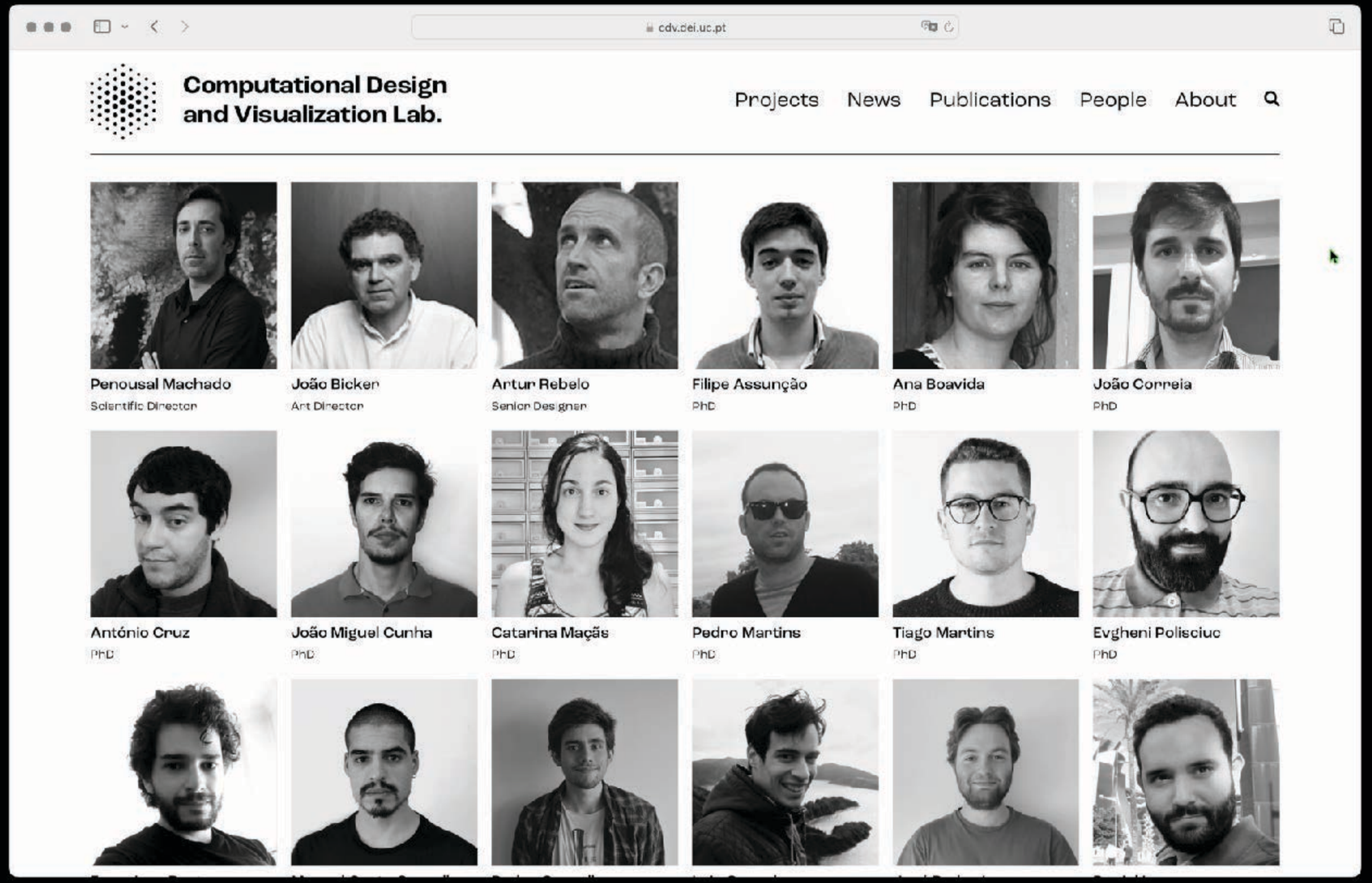
Who am I?

I am a computational designer.

I am a computational designer.

I am a researcher at the Computational Design and Visualization lab, Centre for Informatics and Systems of the University of Coimbra.



CDV Lab. website
cdv.dei.uc.pt

I am a computational designer.

I am a researcher at the Computational Design and Visualization lab, Centre for Informatics and Systems of the University of Coimbra.

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I am a researcher at the Computational Design and Visualization lab, Centre for Informatics and Systems of the University of Coimbra.

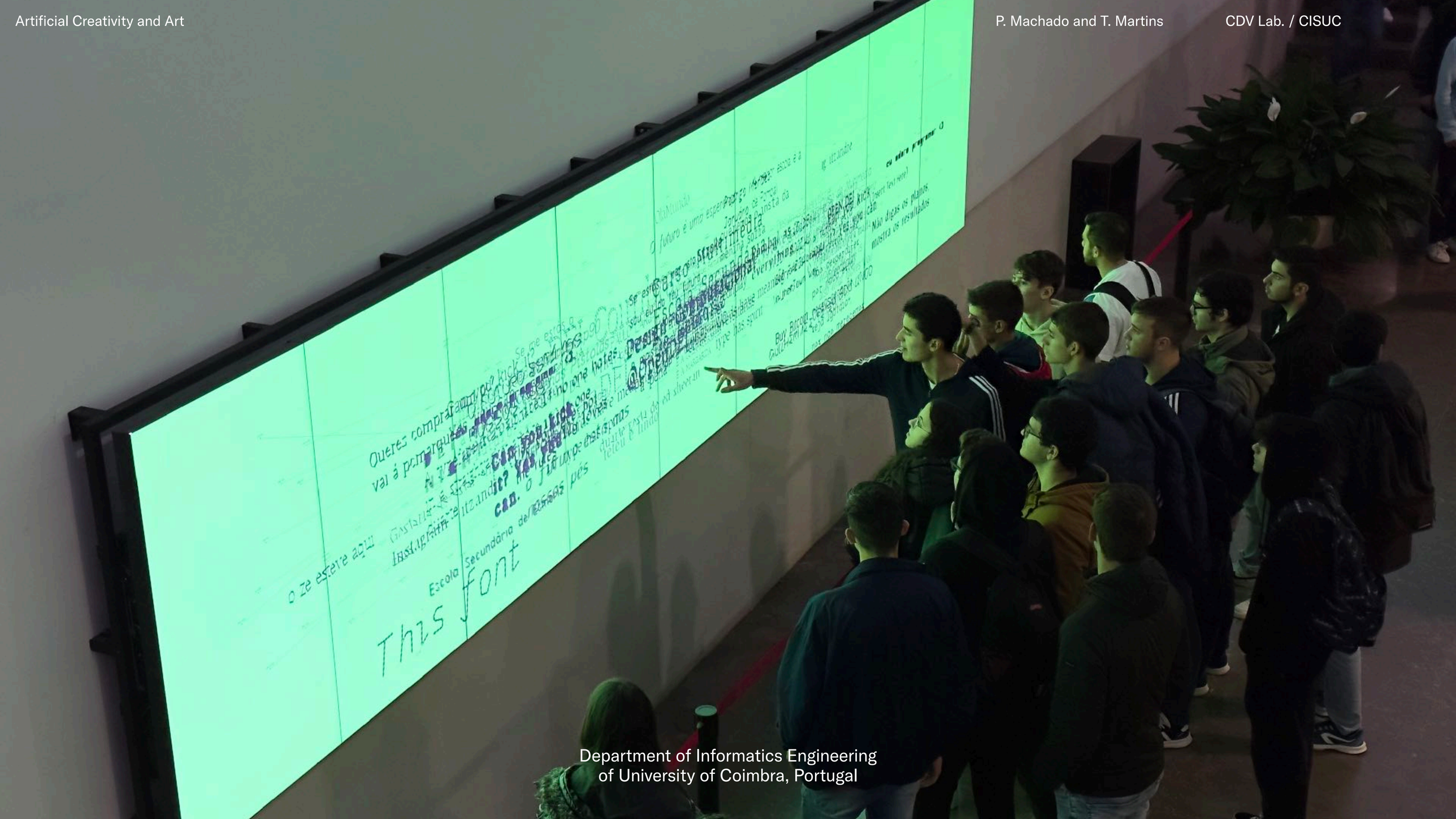
I am a lecturer at Department of Informatics Engineering of University of Coimbra.

P. Machado and T. Martins

CDV Lab. / CISUC

Department of Informatics Engineering
of University of Coimbra, Portugal

P. Machado and T. Martins CDV Lab. / CISUC



Department of Informatics Engineering
of University of Coimbra, Portugal

Generative Design and Visual Art

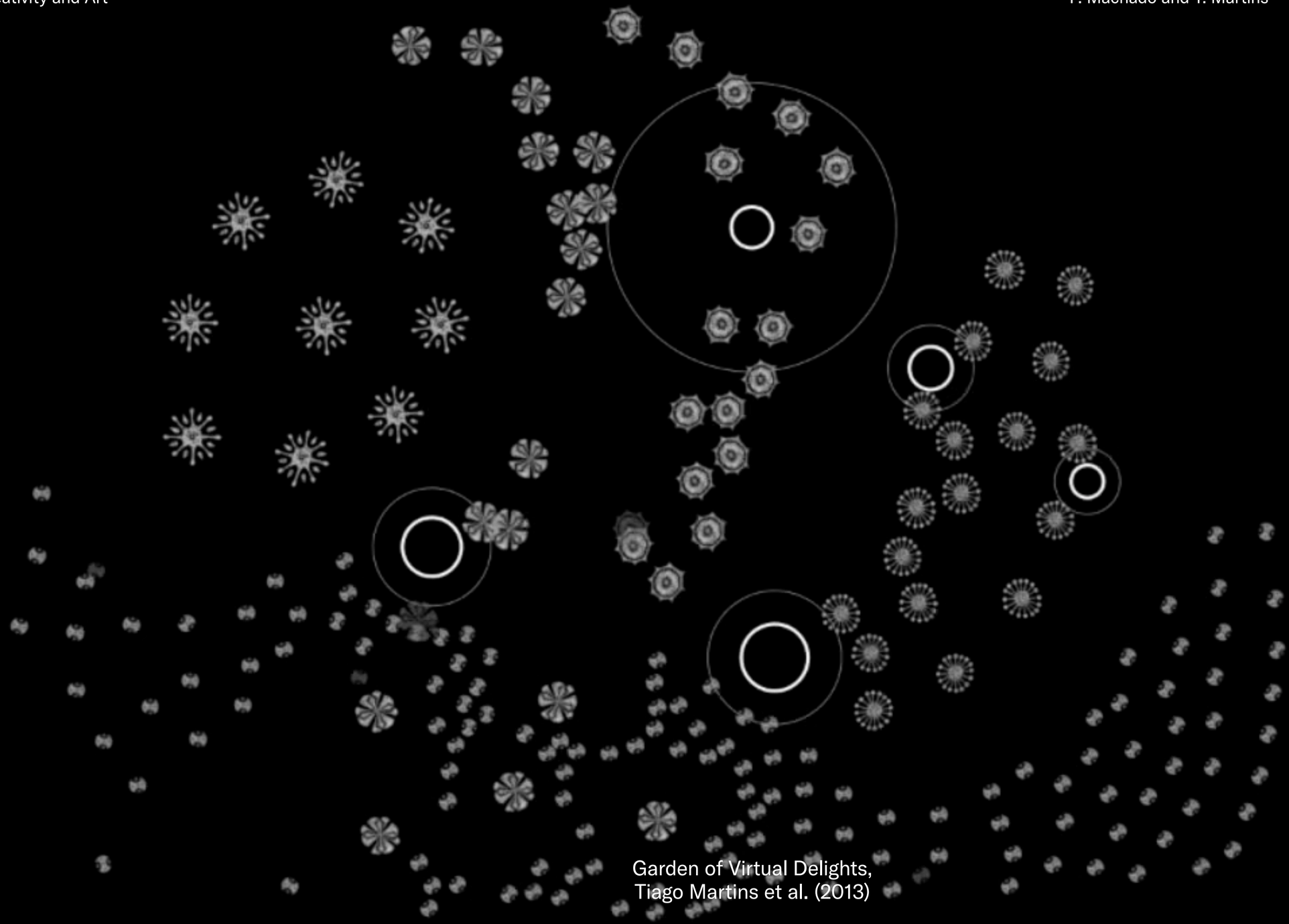
Generative Design and Visual Art

New Media Art

Generative Design and Visual Art

New Media Art

Artificial Intelligence



Garden of Virtual Delights,
Tiago Martins et al. (2013)

Use of Artificial Intelligence to generate new visual artefacts.

Use of Artificial Intelligence to generate new visual artefacts.

Propose novel tools to go beyond existing options.

Use of Artificial Intelligence to generate new visual artefacts.

Propose novel tools to go beyond existing options.

Explore vast spaces of unique designs through evolutionary computation.

Generating
letters

Generating
faces

Generating
coins

Generating
letters

Generating
faces

Generating
coins

Generating
harmonographs

Generating
letters

Generating
faces

Generating
coins

Co-authored with João Correia,
Ernesto Costa, and Penousal Machado

Context

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- Typefaces are essential in several design domains;

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- Continuous creation of new custom typefaces;

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- Designing a typeface is a laborious task;

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- Existing computational tools offer little support to design exploration;

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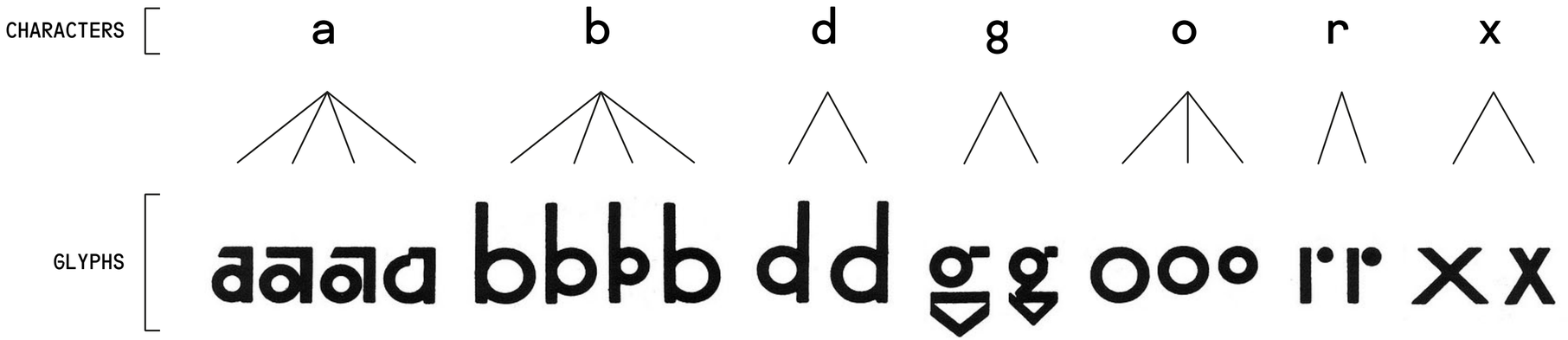
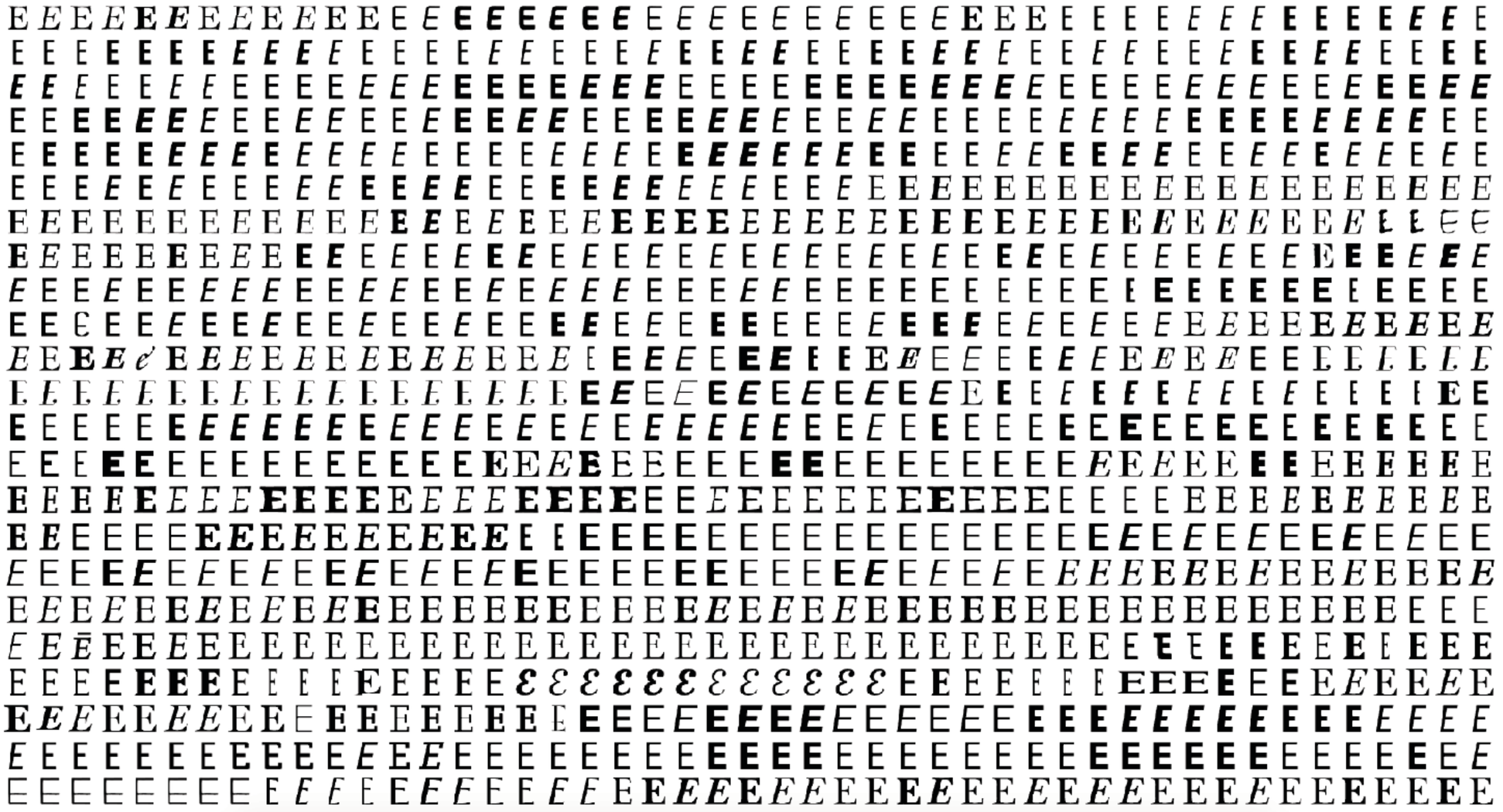
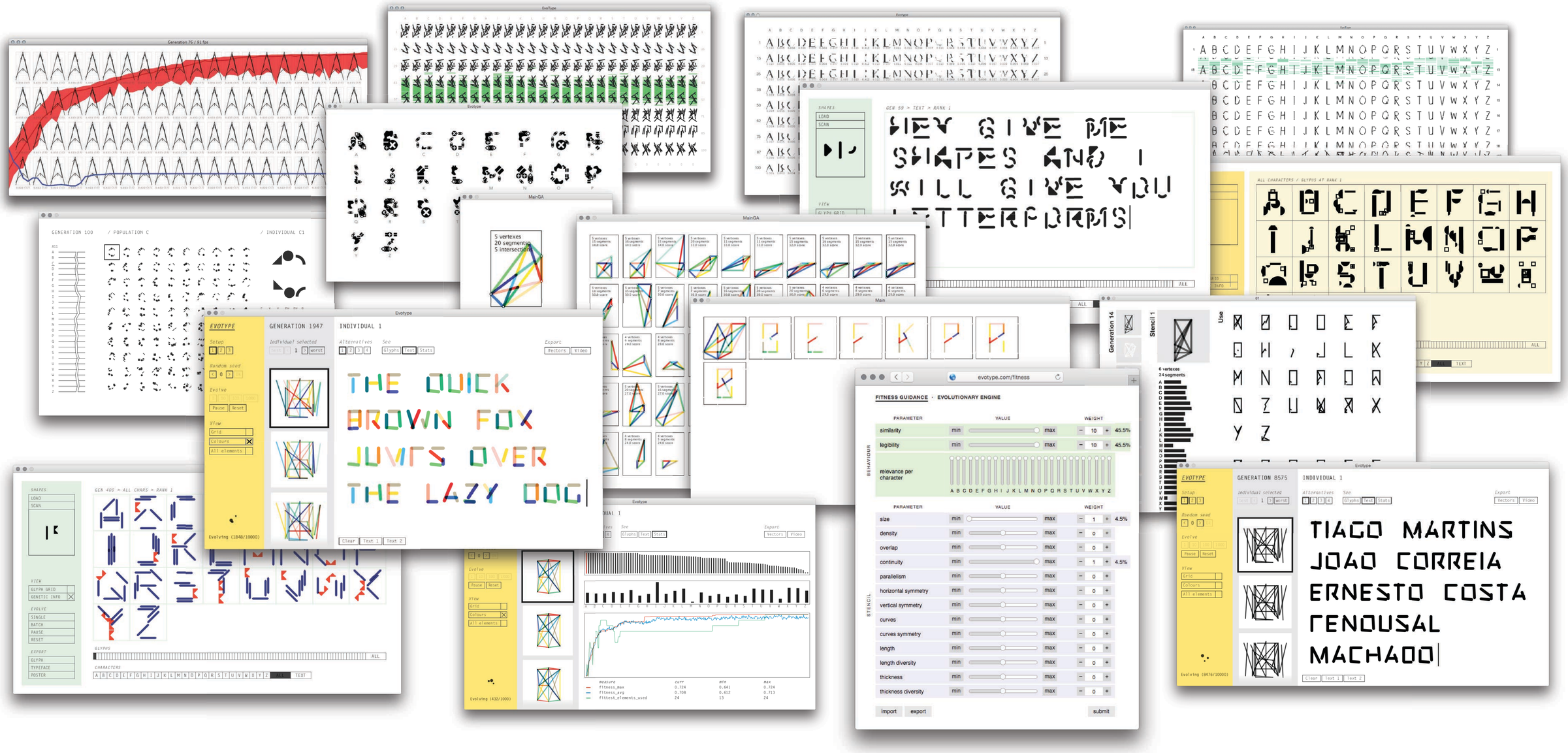
- Typefaces are essential in several design domains;
- Continuous creation of new custom typefaces;
- Designing a typeface is a laborious task;
- Existing computational tools offer little support to design exploration;
- Demand for tools that enable the quick generation of glyph designs.



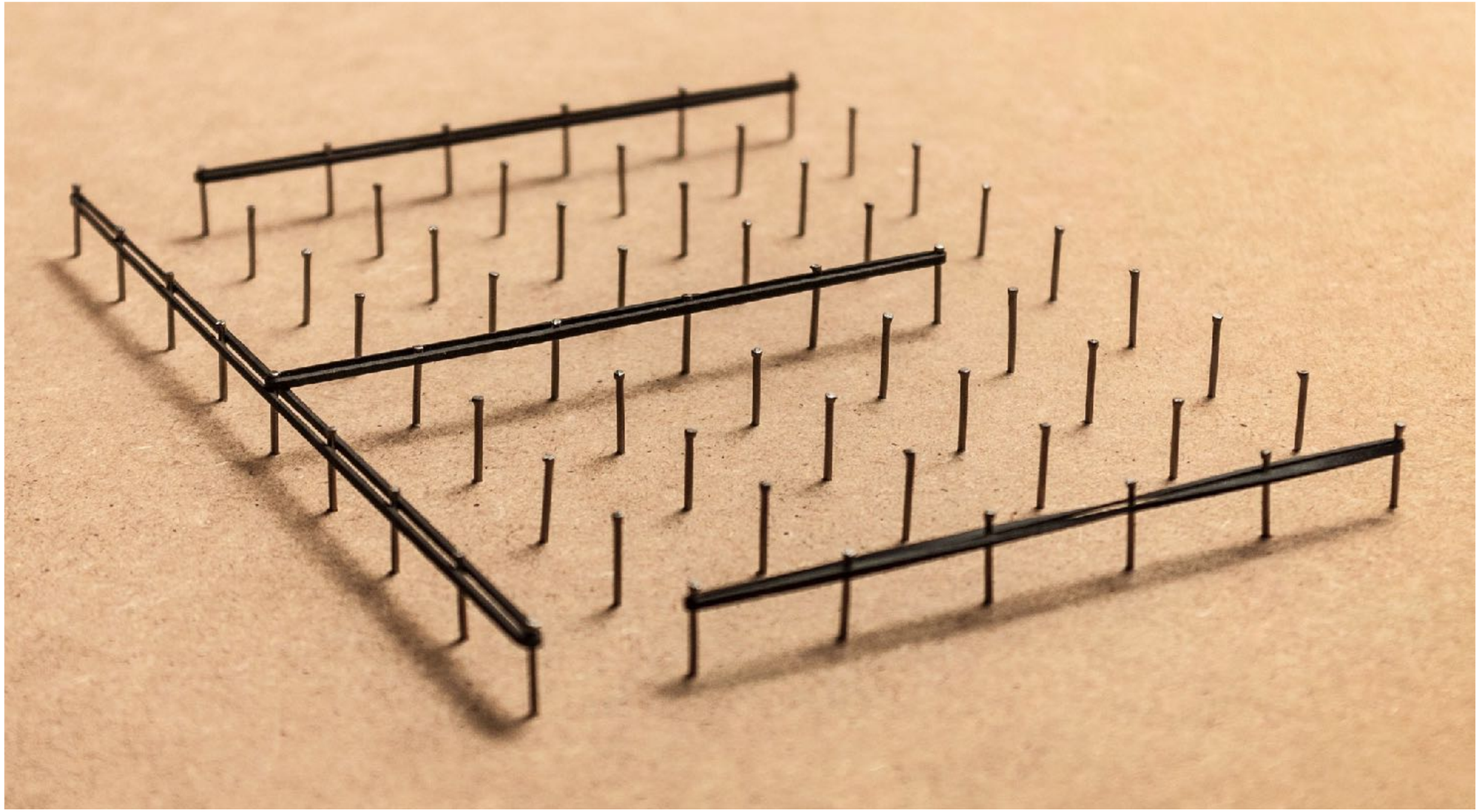
Characters and glyphs



Different glyphs for the letter E

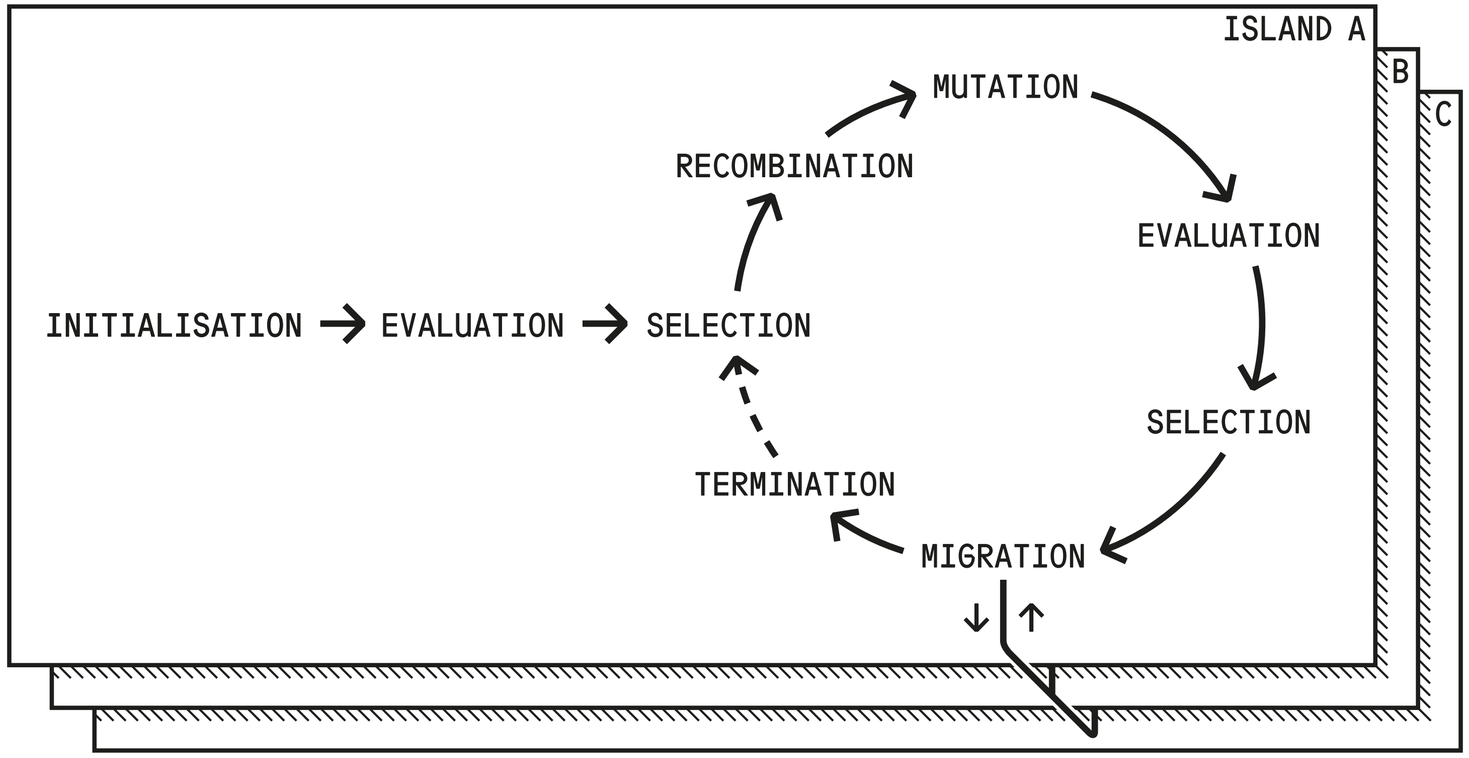


Screenshots of different computer systems developed for *Evotype*

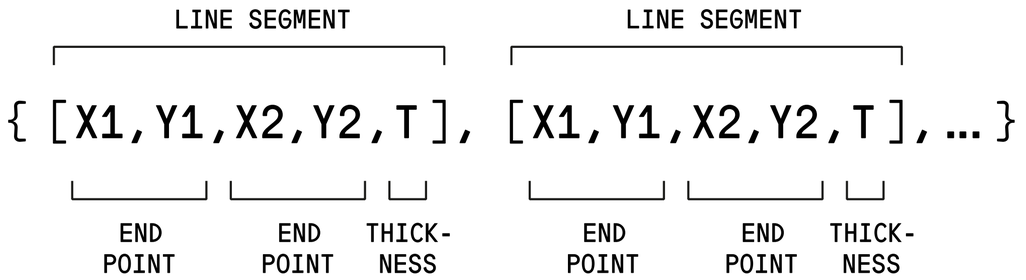


Glyph for the letter E designed with
rubber bands in a grid of iron nails

Video of the evolutionary process of Evotype

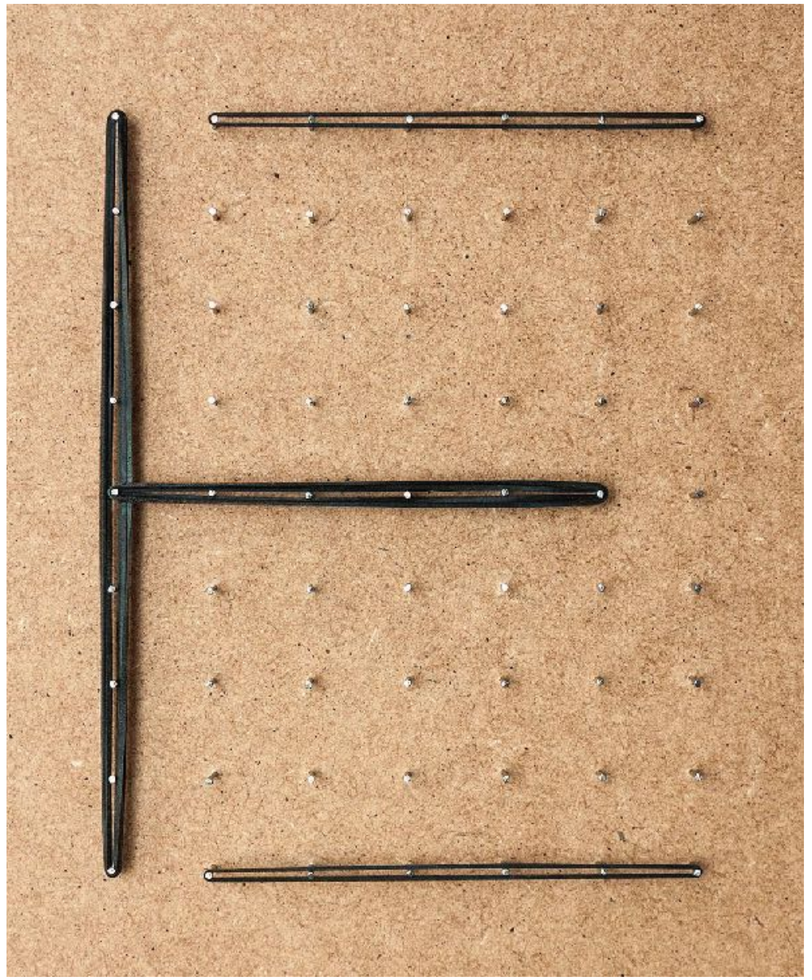


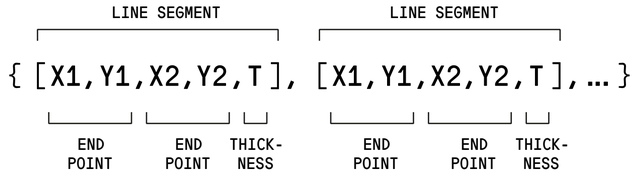
Overview of Evotype



Genotype encoding

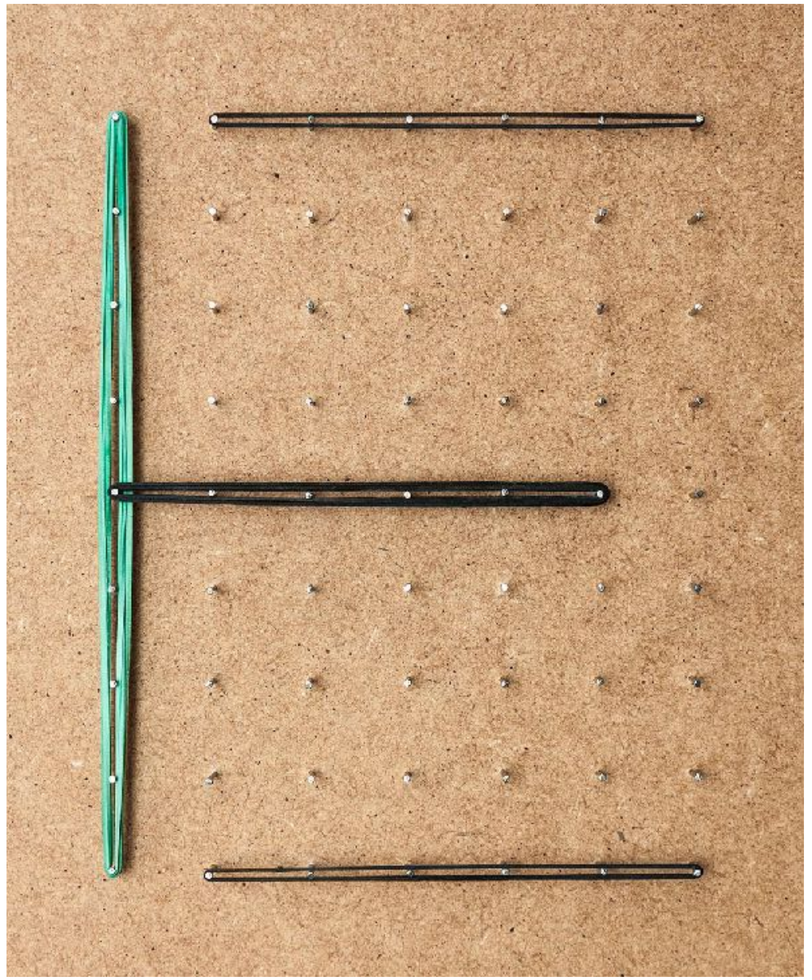
```
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```

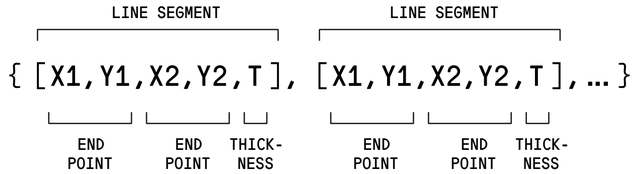




Mapping process from genotype to phenotype

```
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```





Mapping process from genotype to phenotype

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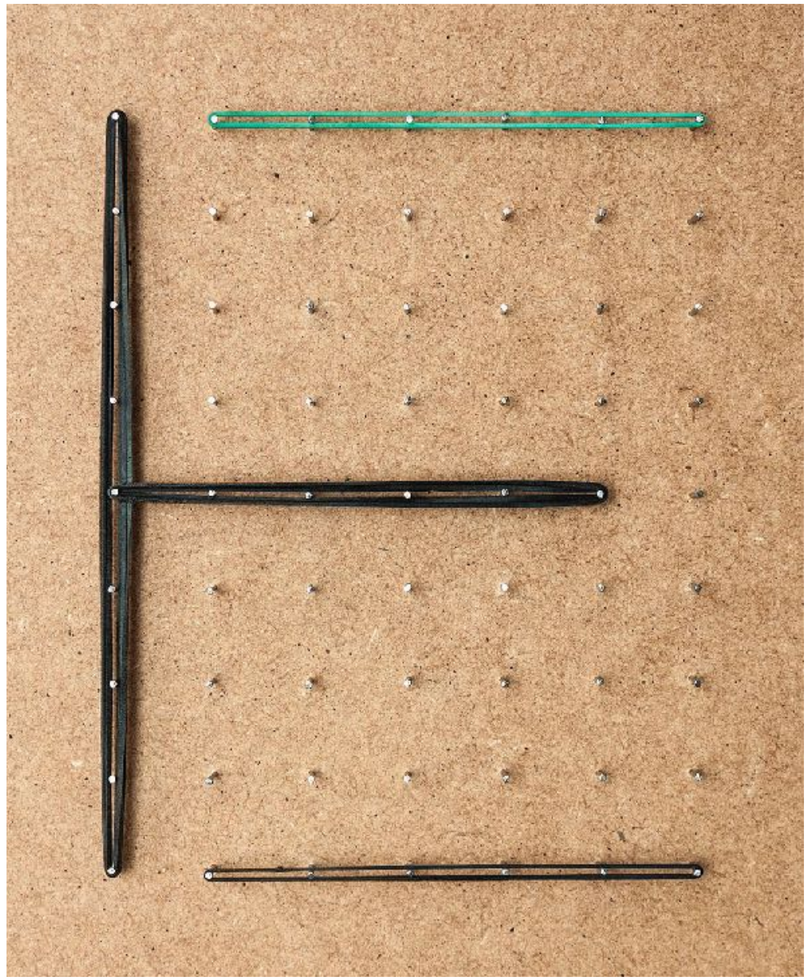
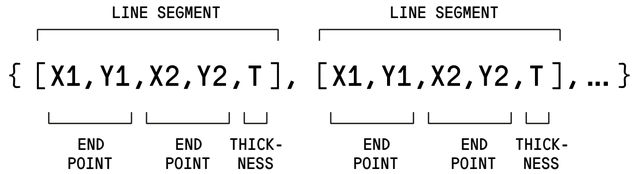
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```





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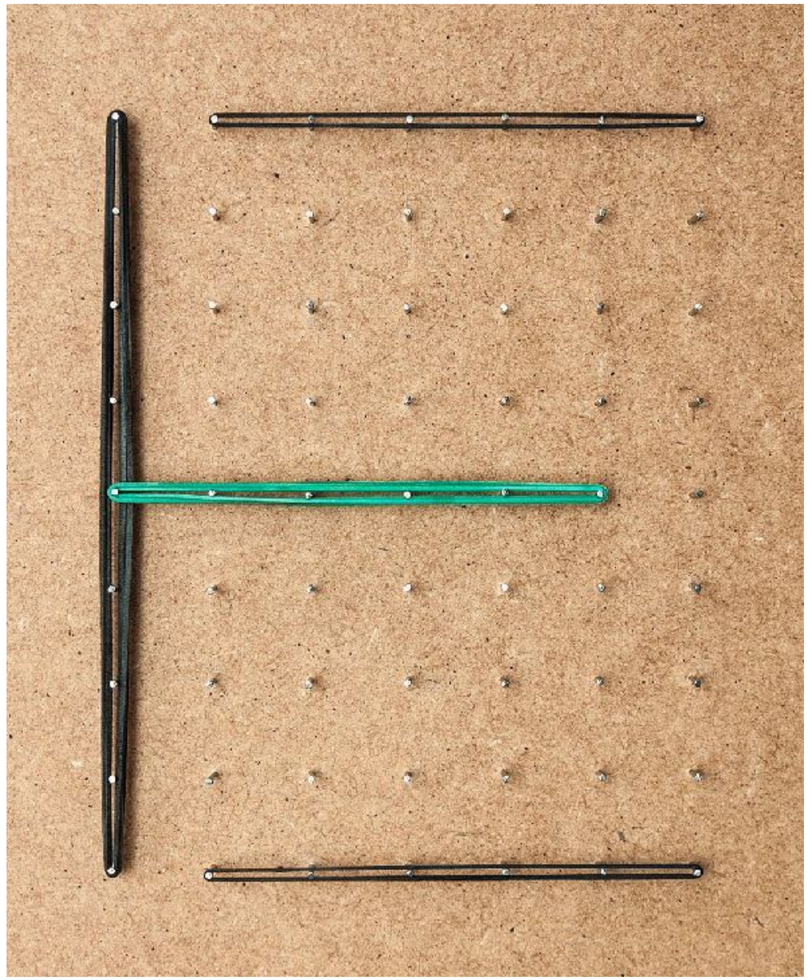
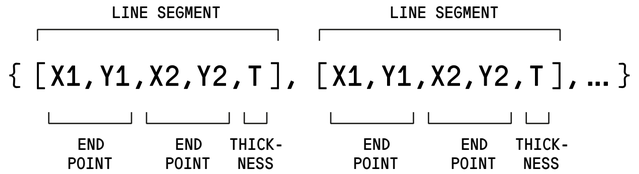
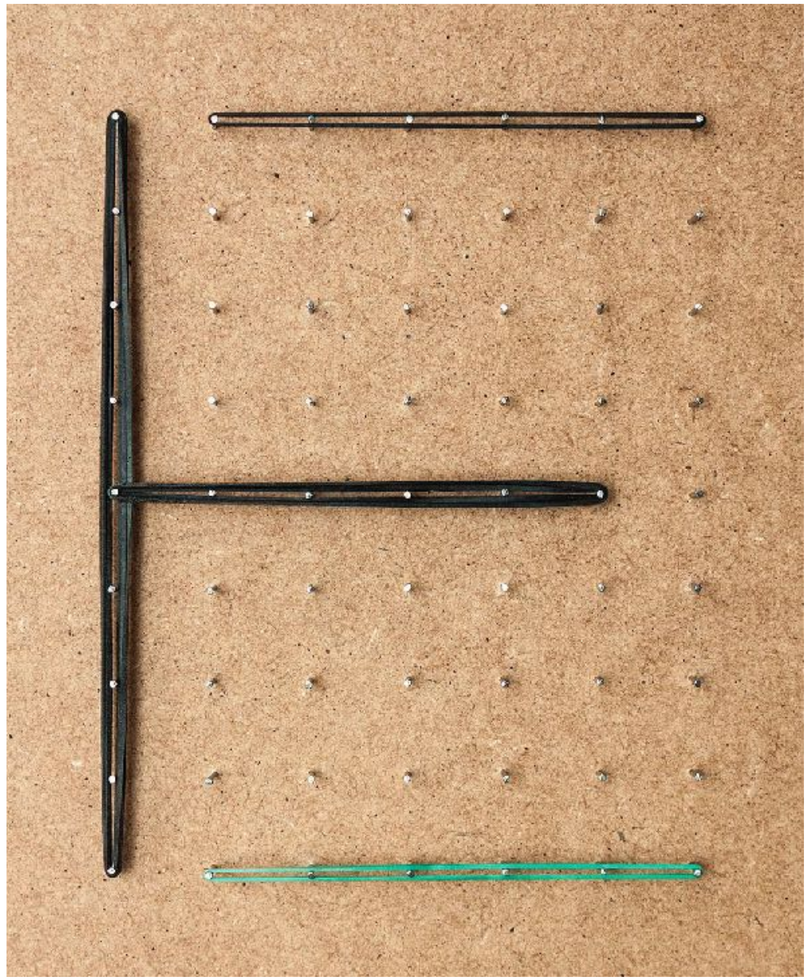
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```

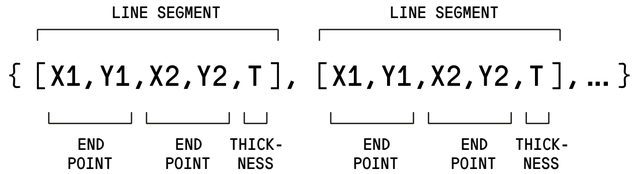




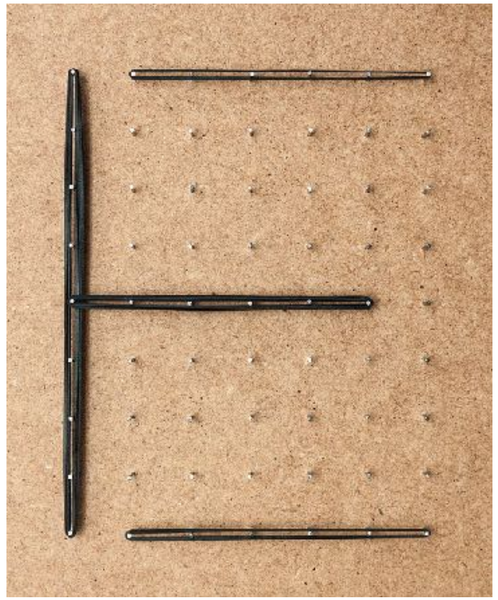
Mapping process from genotype to phenotype

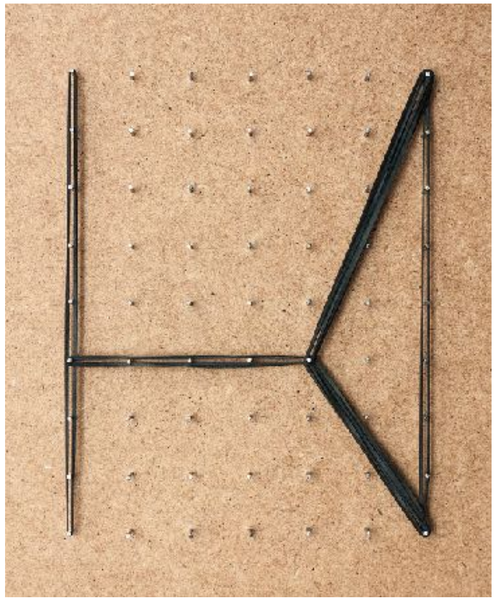
```
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```





Mapping process from genotype to phenotype

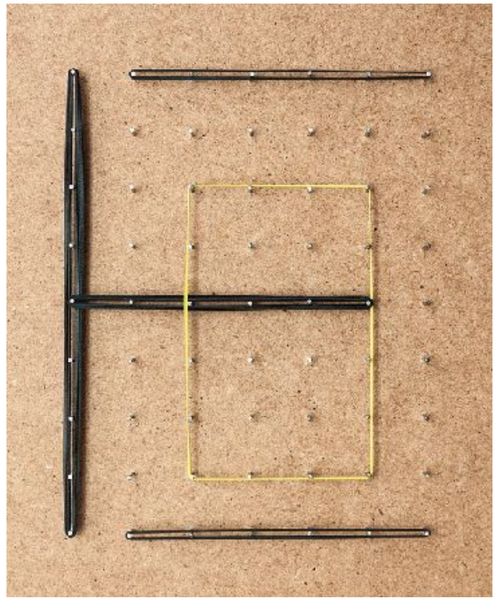




```
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```

```
{[0,0,0,8,1],
 [0,5,4,5,1],
 [6,0,6,8,1],
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

Crossover process



```
{[0,0,0,8,3],
 [1,0,6,0,1],
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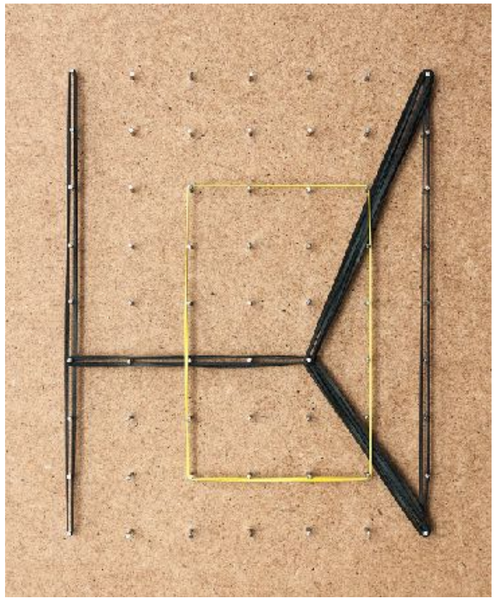
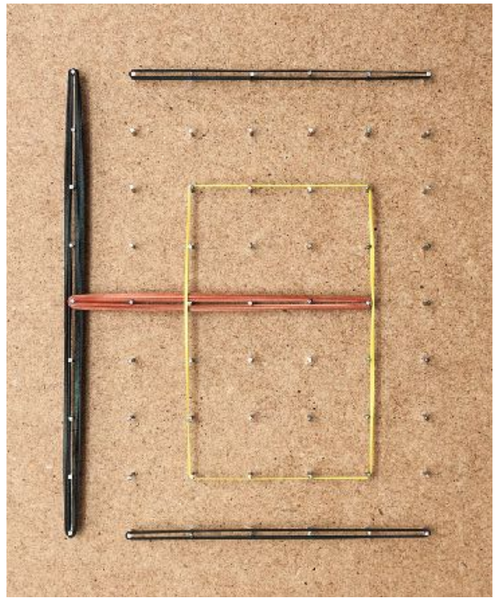
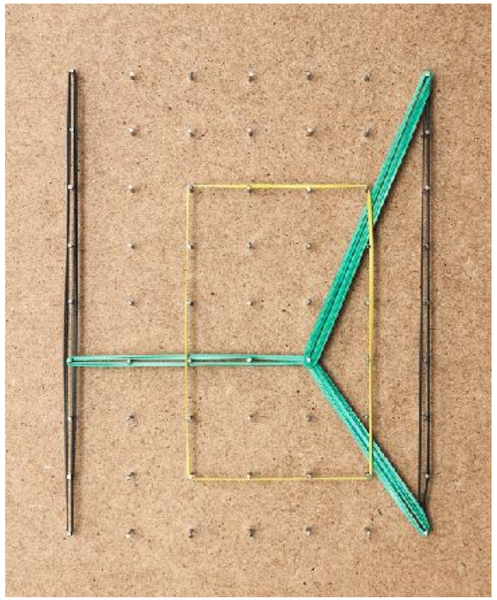
 [1,8,6,8,1]}
```



```
{[0,0,0,8,1],
 [0,5,4,5,1],
 [6,0,6,8,1],
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

Crossover process

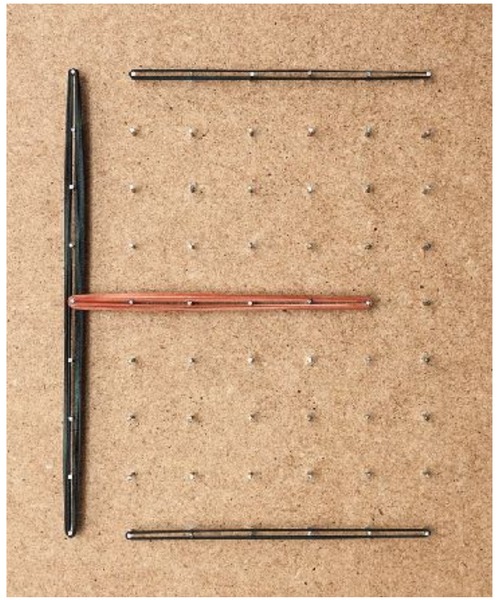




```
{[0,0,0,8,3],
 [1,0,6,0,1],
 [0,4,5,4,2],
 [1,8,6,8,1]}
```

```
{[0,0,0,8,1],
 [0,5,4,5,1],
 [6,0,6,8,1],
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

Crossover process



```
{[0,0,0,8,3],
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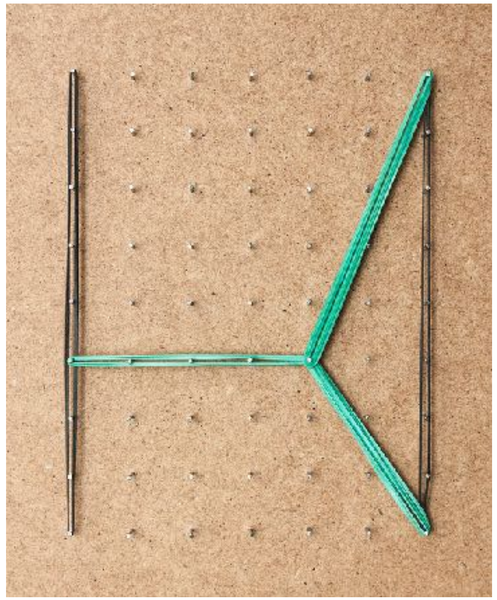
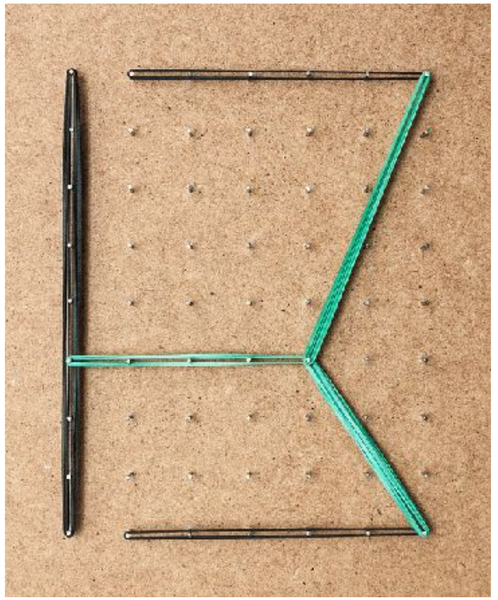
 [1,8,6,8,1]}
```



```
{[0,0,0,8,1],
 [0,5,4,5,1],
 [6,0,6,8,1],
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

→



```
{[0,0,0,8,3],
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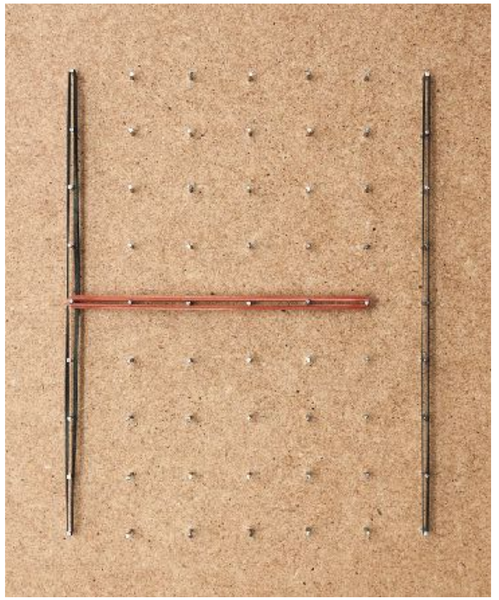
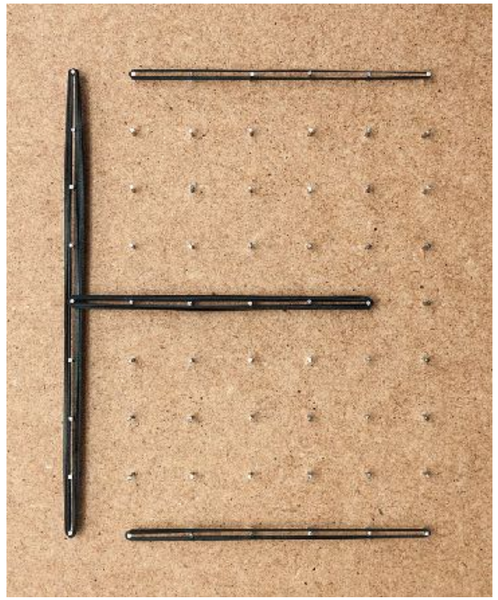
```



```
{[0,0,0,8,1],
 [6,0,6,8,1],
 [0,4,5,4,2]}
```

Crossover process



```
{[0,0,0,8,3],
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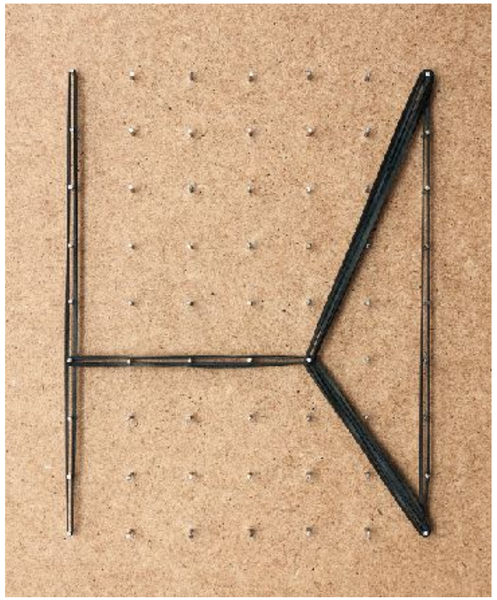
 [1,8,6,8,1]}
```



```
{[0,0,0,8,1],
 [0,5,4,5,1],
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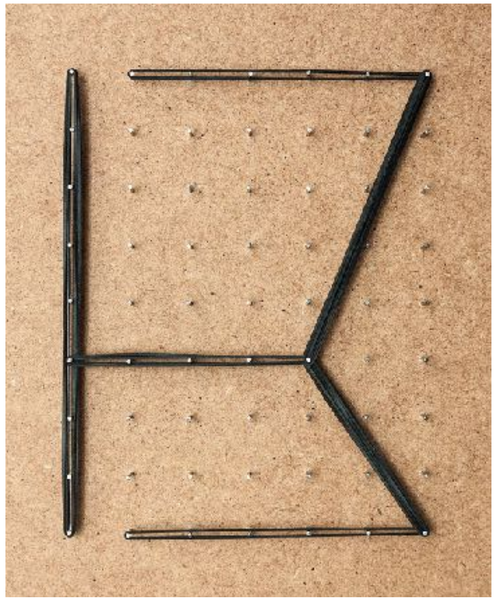
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

→



```
{[0,0,0,8,3],
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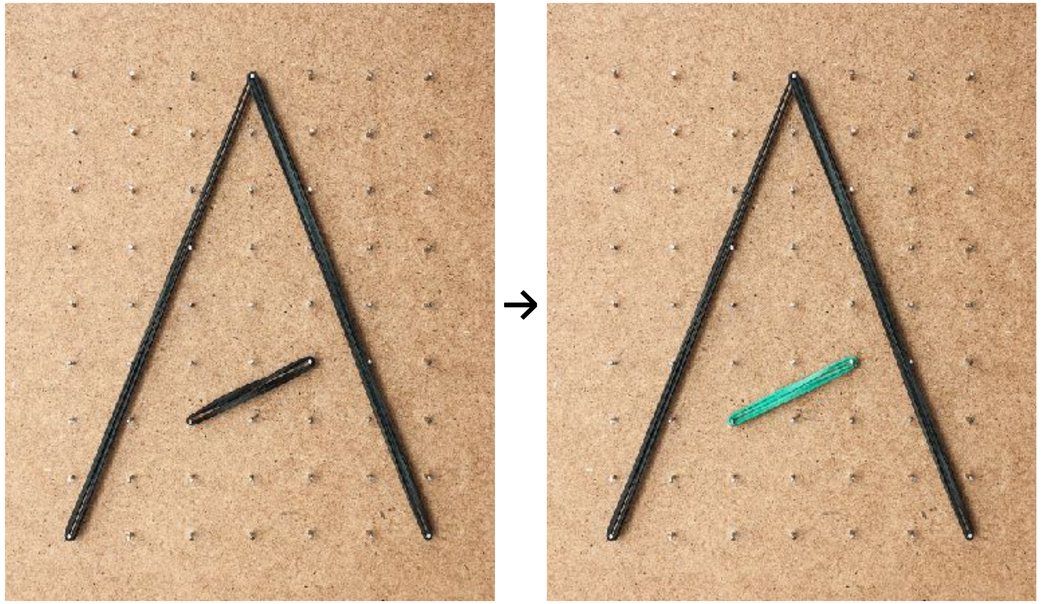
 [1,8,6,8,1],
 [0,5,4,5,1],
 [6,0,4,5,4],
 [6,8,4,5,4]}
```

```
{[0,0,0,8,1],
 [6,0,6,8,1],
 [0,4,5,4,2]}
```

Crossover process

```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,6,2]}
```

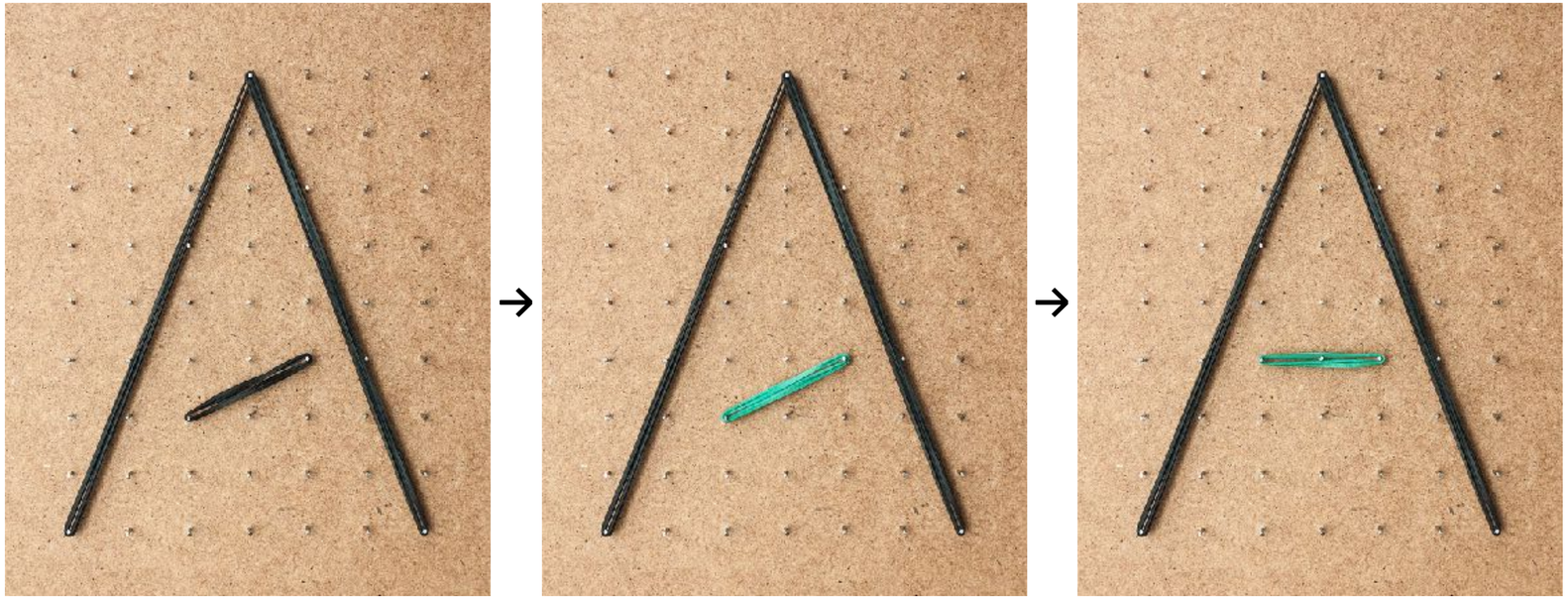
Mutation process



```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,6,2]}
```

```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,6,2]}
```

Mutation process

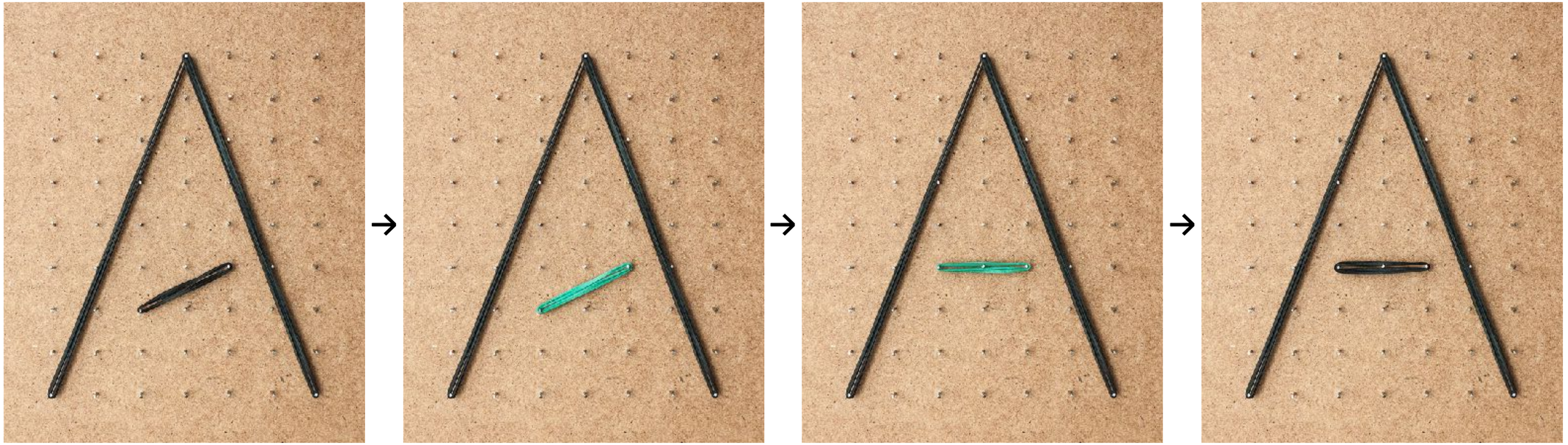


```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,6,2]}
```

```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,6,2]}
```

```
{[3,0,0,8,2],
 [3,0,6,8,3],
 [4,5,2,5,2]}
```

Mutation process



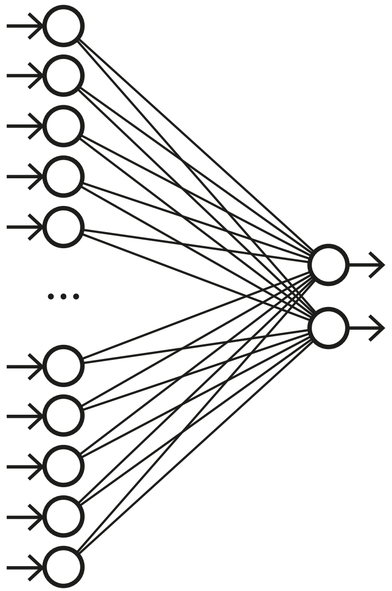
{[3,0,0,8,2],
[3,0,6,8,3],
[4,5,2,6,2]}

{[3,0,0,8,2],
[3,0,6,8,3],
[4,5,2,6,2]}

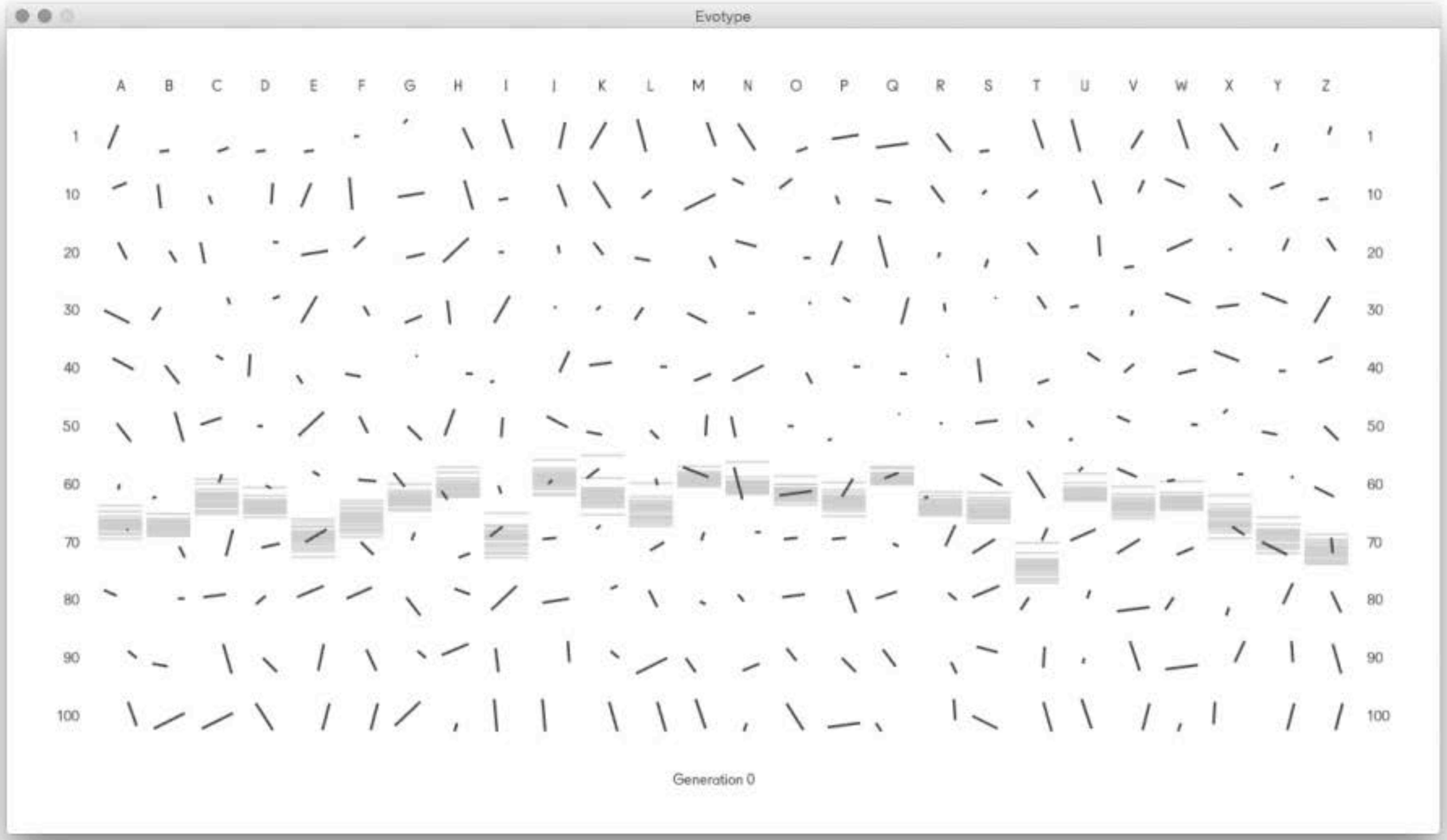
{[3,0,0,8,2],
[3,0,6,8,3],
[4,5,2,5,2]}

{[3,0,0,8,2],
[3,0,6,8,3],
[4,5,2,5,2]}

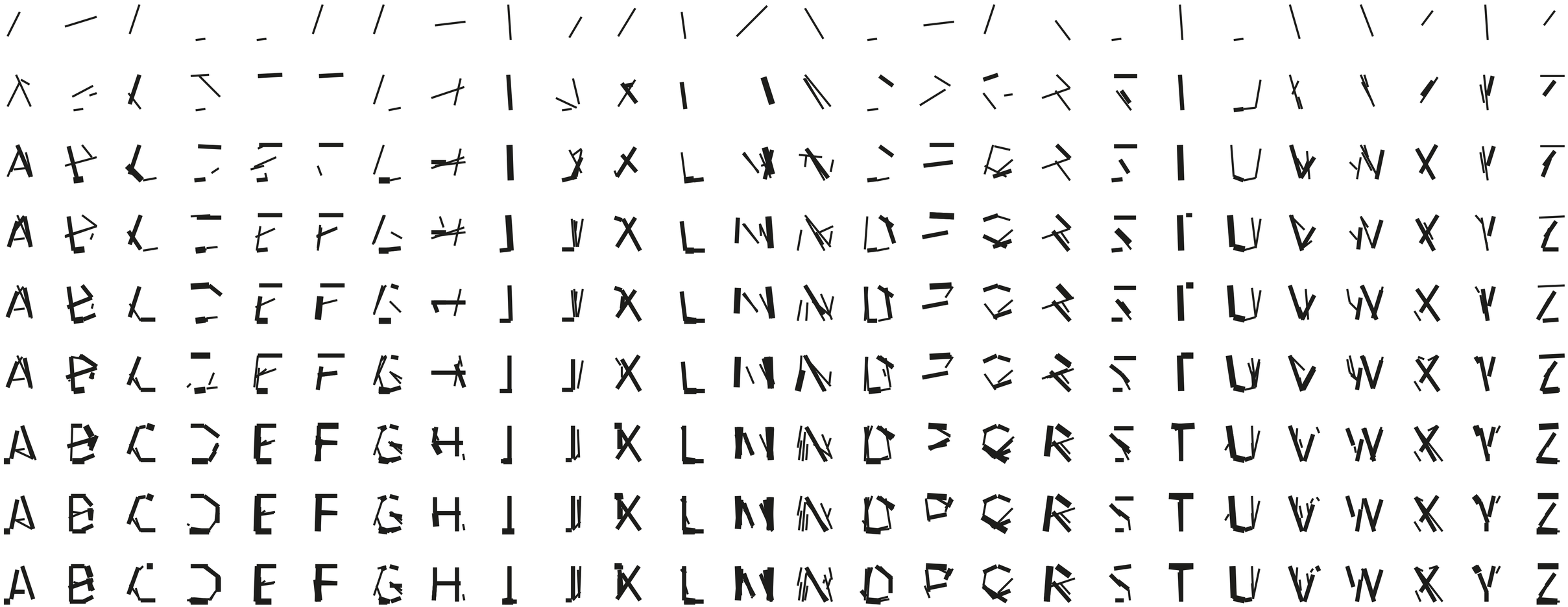
Mutation process



SNoW (Sparse Network of Winnows)

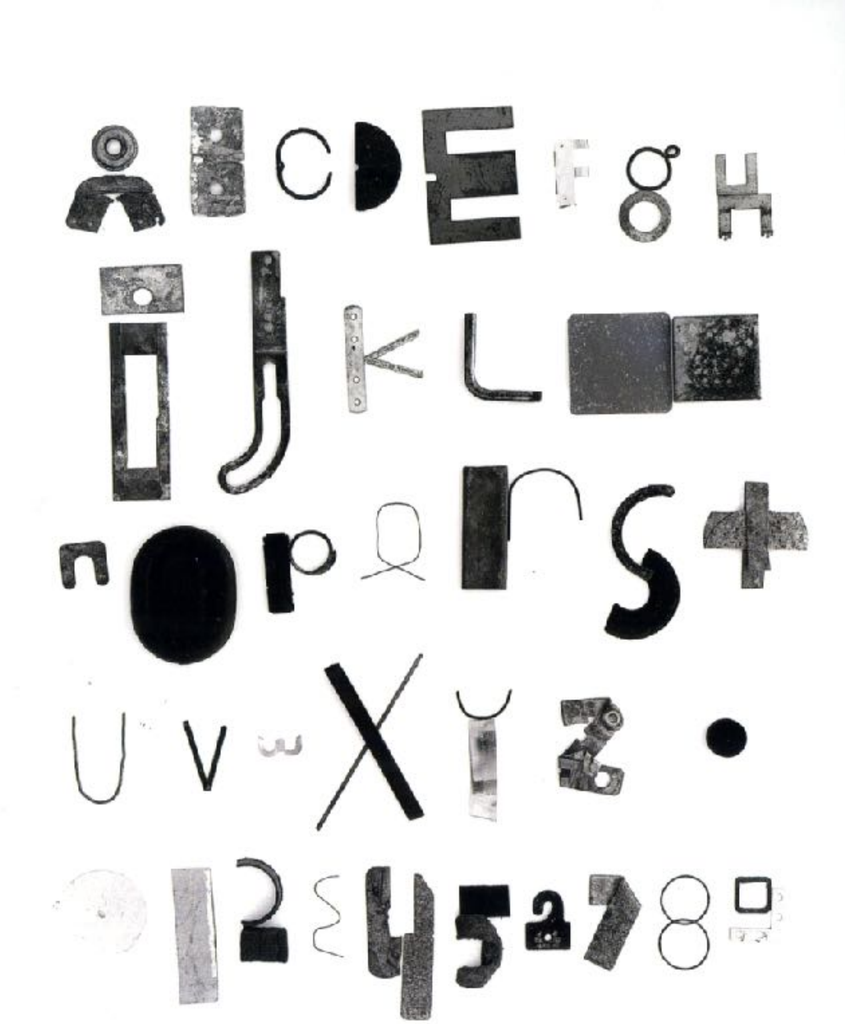


Evotype system

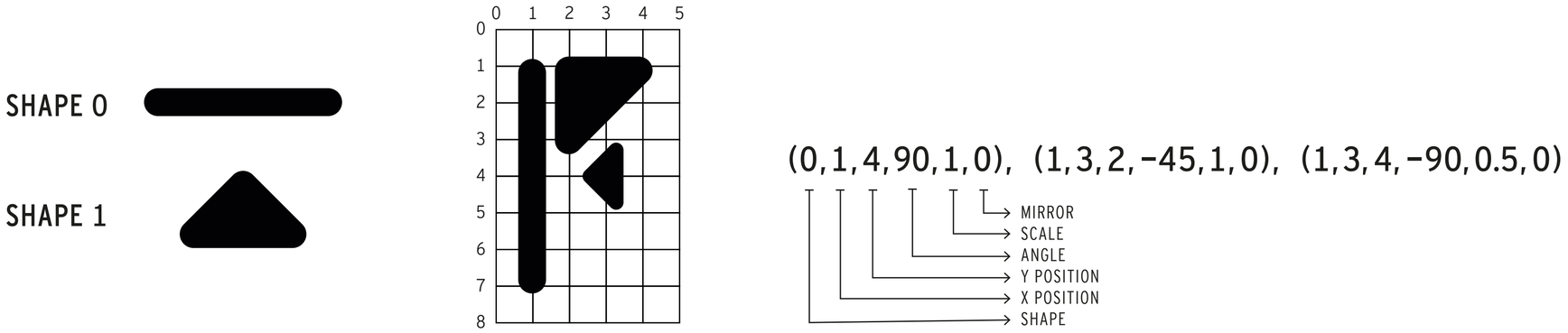


Best individuals of each island for different generations from a typical run

Examples of glyph designs evolved
in different evolutionary runs



Found Fount by Paul Elliman



Encoding example

my own shapes.svg

SHAPES

LOAD

SCAN

VIEW

GLYPH GRID

GENETIC INFO

EVOLVE

SINGLE

BATCH

PAUSE

RESET

EXPORT

GLYPH

TYPEFACE

POSTER

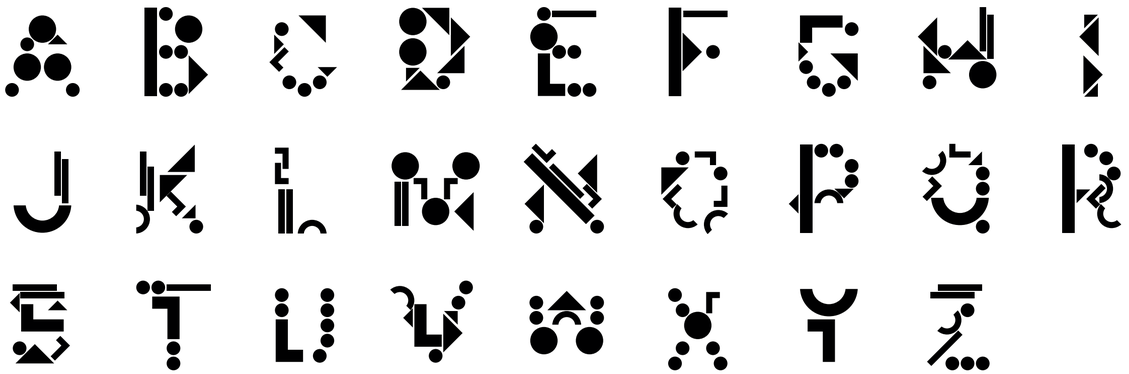
GEN 0 > ALL CHARS > RANK 1

GLYPHS

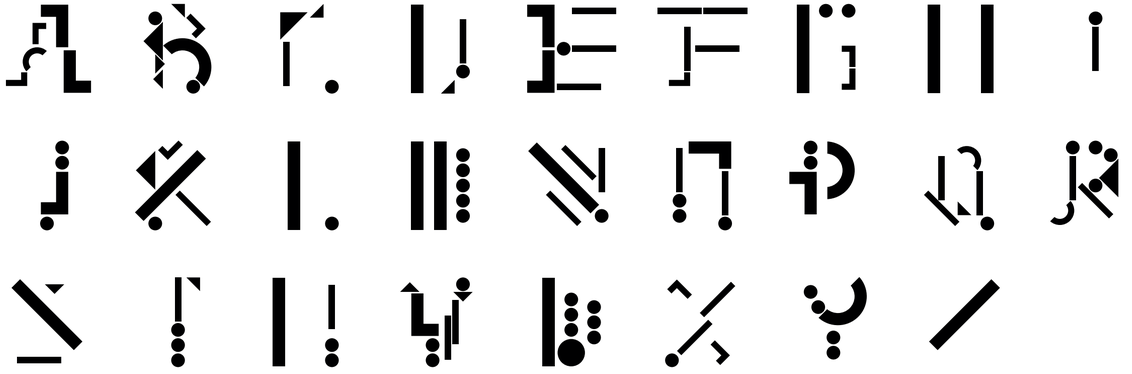
CHARACTERS

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z ALL

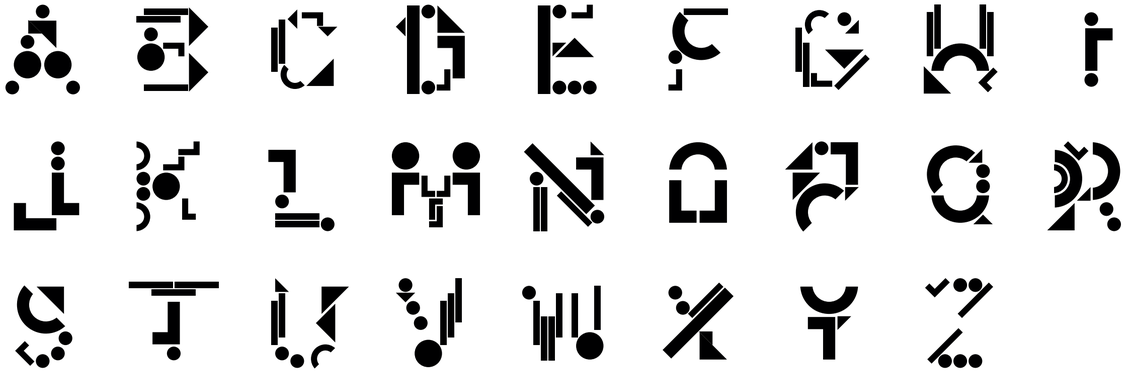
Example of input shapes



RMSE

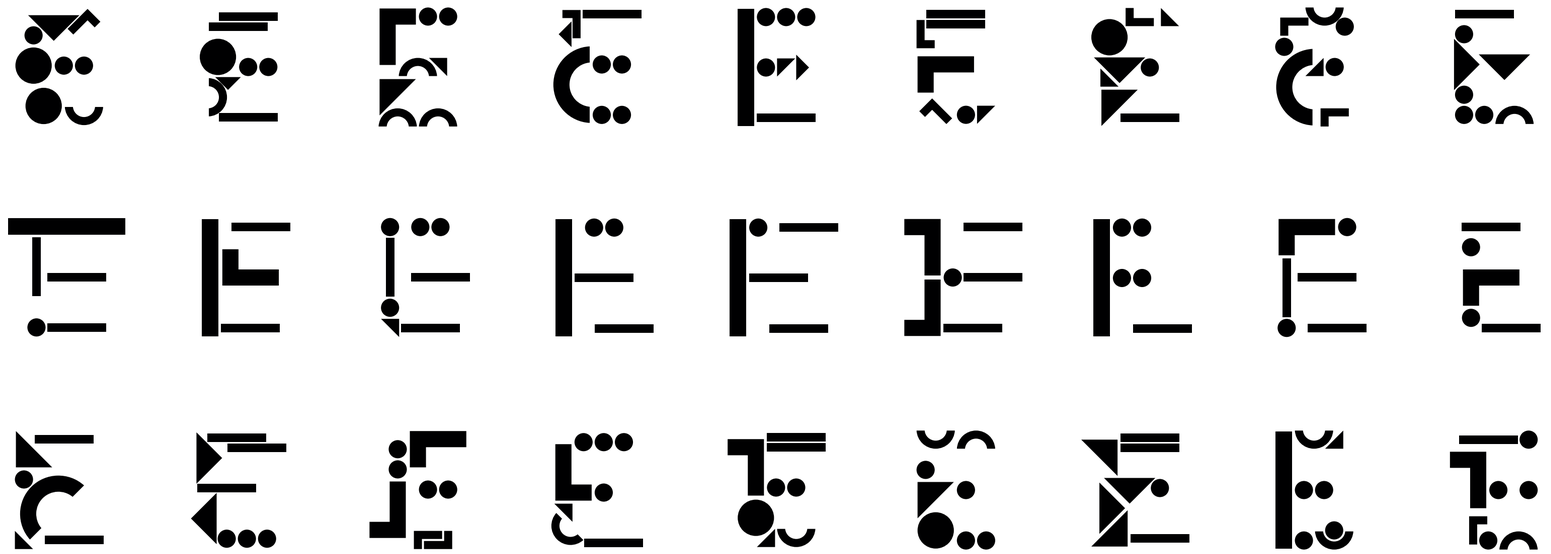


CNN

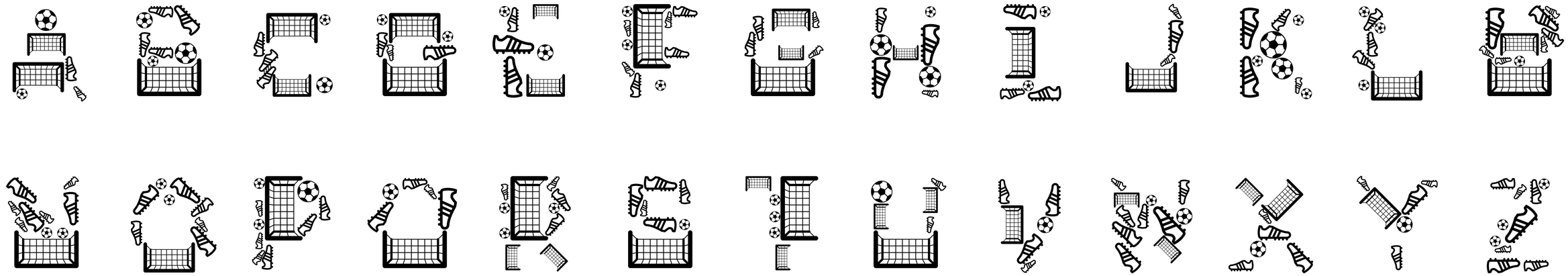


Hybrid

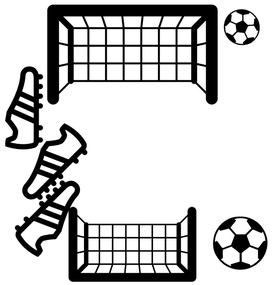
Typical glyphs evolved with *Evotype II*
using different fitness functions

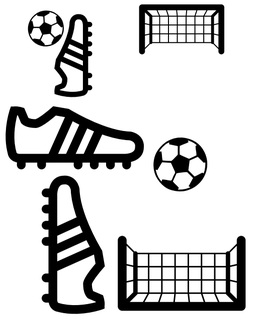
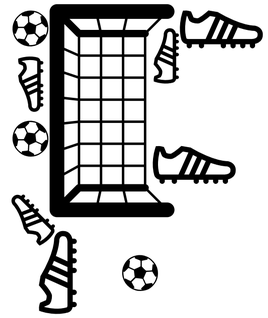


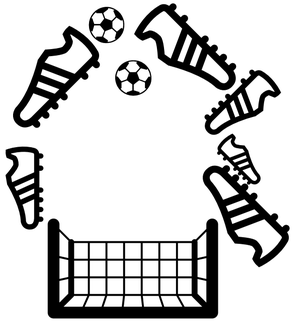
Different Es in the last generation

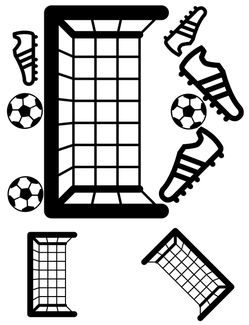
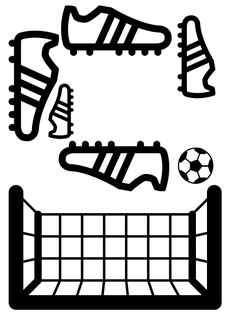


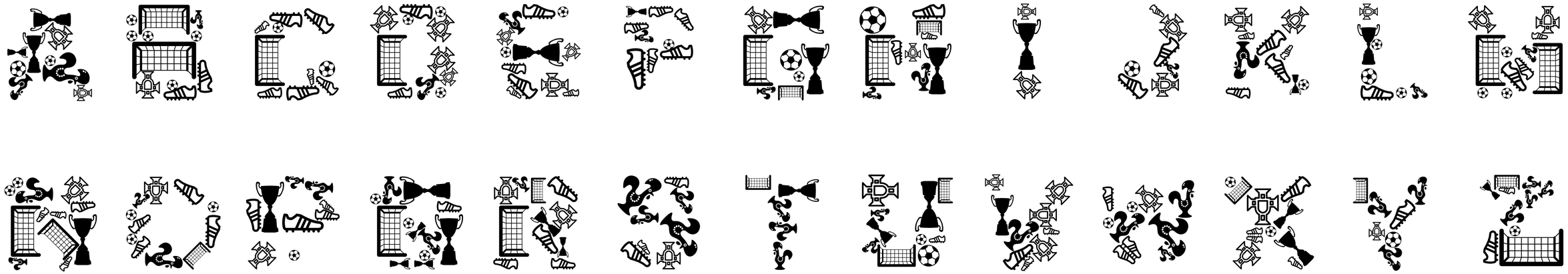


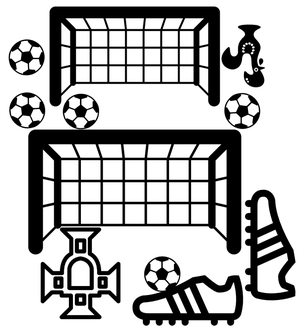


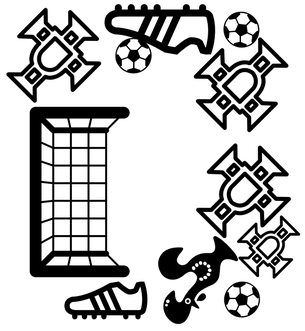



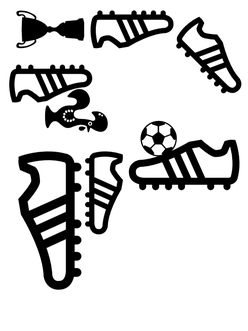


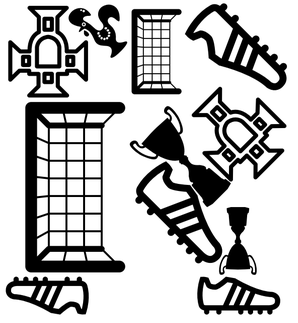


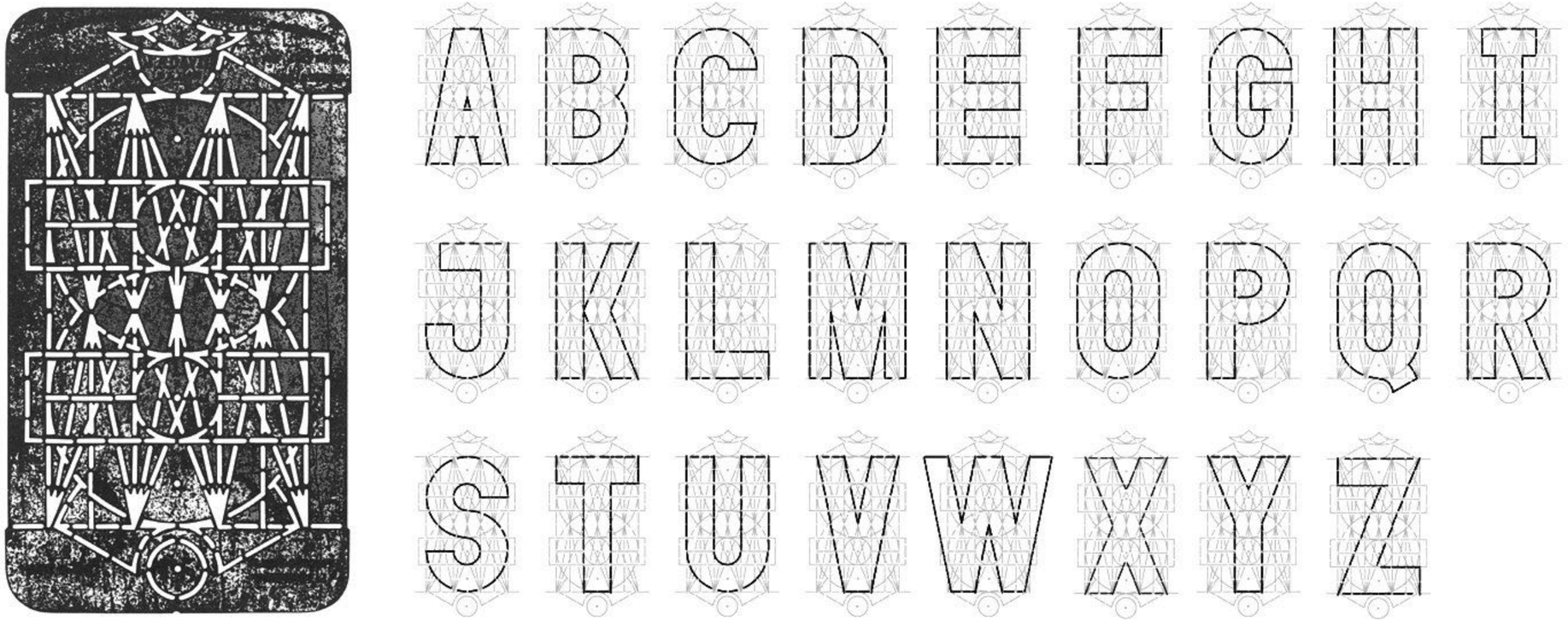






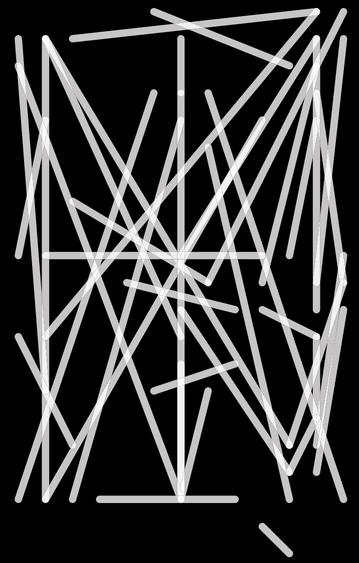




IF EVERYONE
WERE CAST
IN THE SAME
MOLD, THERE
WOULD BE NO
SUCH THING
AS BEAUTY

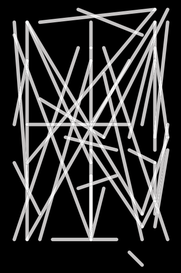


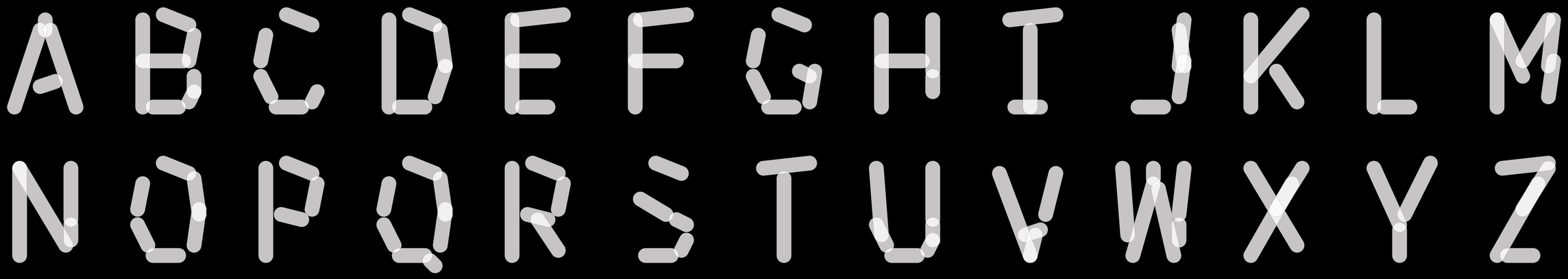
Plaque Découpée Universelle,
Joseph A. David, 1876

Seven-segment display

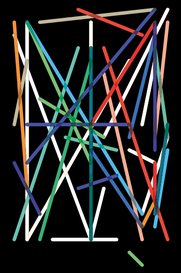


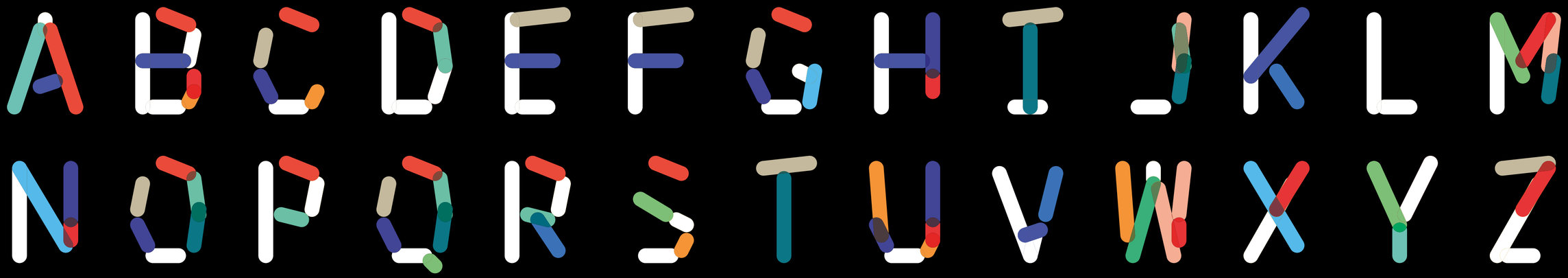
Evolved stencil



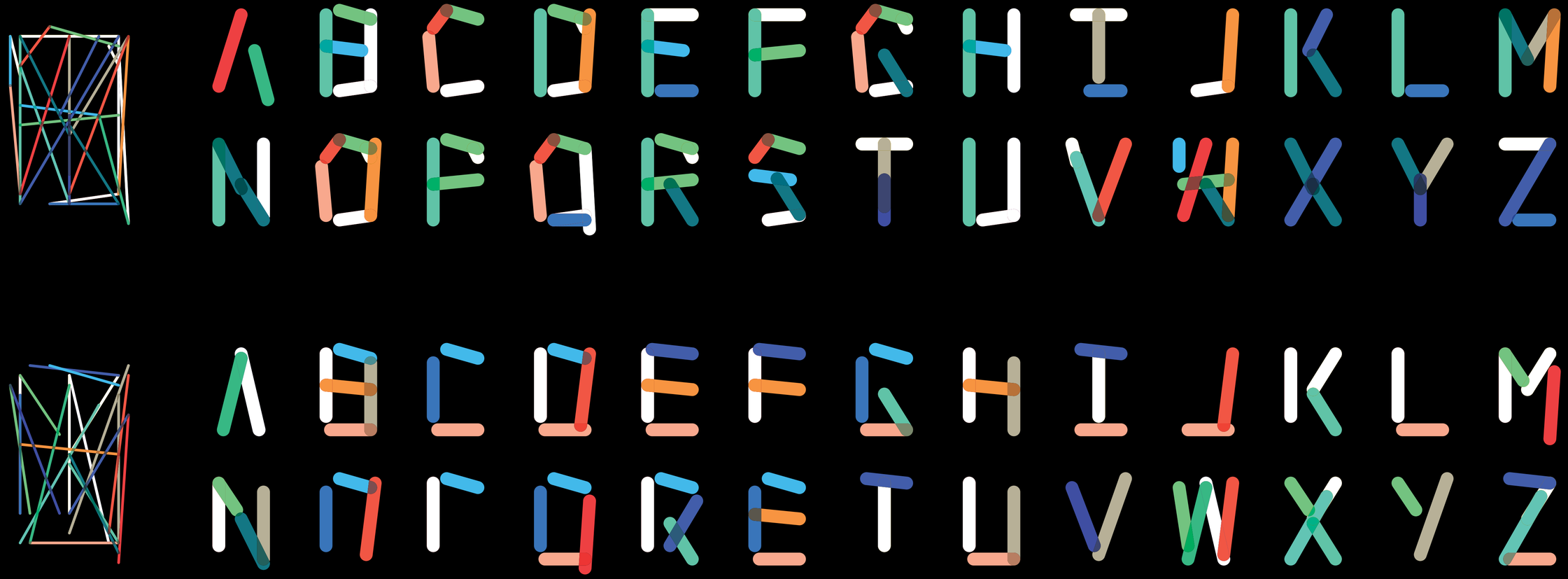


Letters drawn with evolved stencil





Letters drawn with evolved stencil



Letters drawn with two evolved stencils

GENERATION 0

STENCIL 1

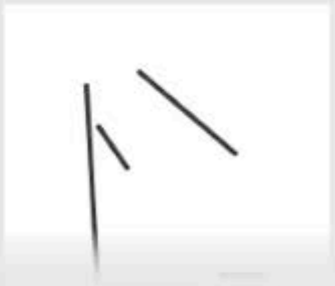
Setup
1 2 3

Random seed
< 0 > OK

Evolve
1 10 100 1000
Pause Reset

View
Grid
Colours
All elements

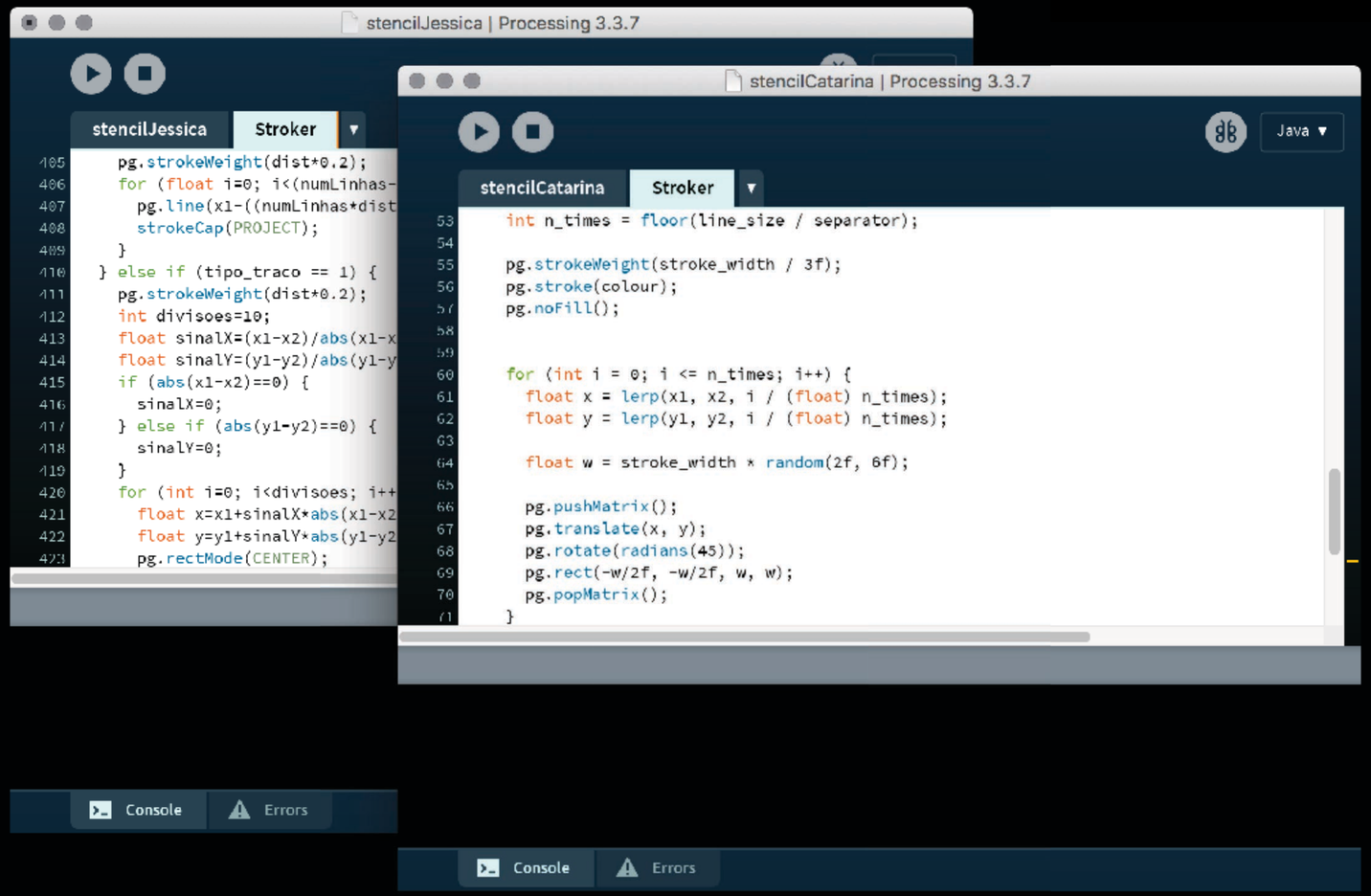
Stencil selected
best < 1 > worst



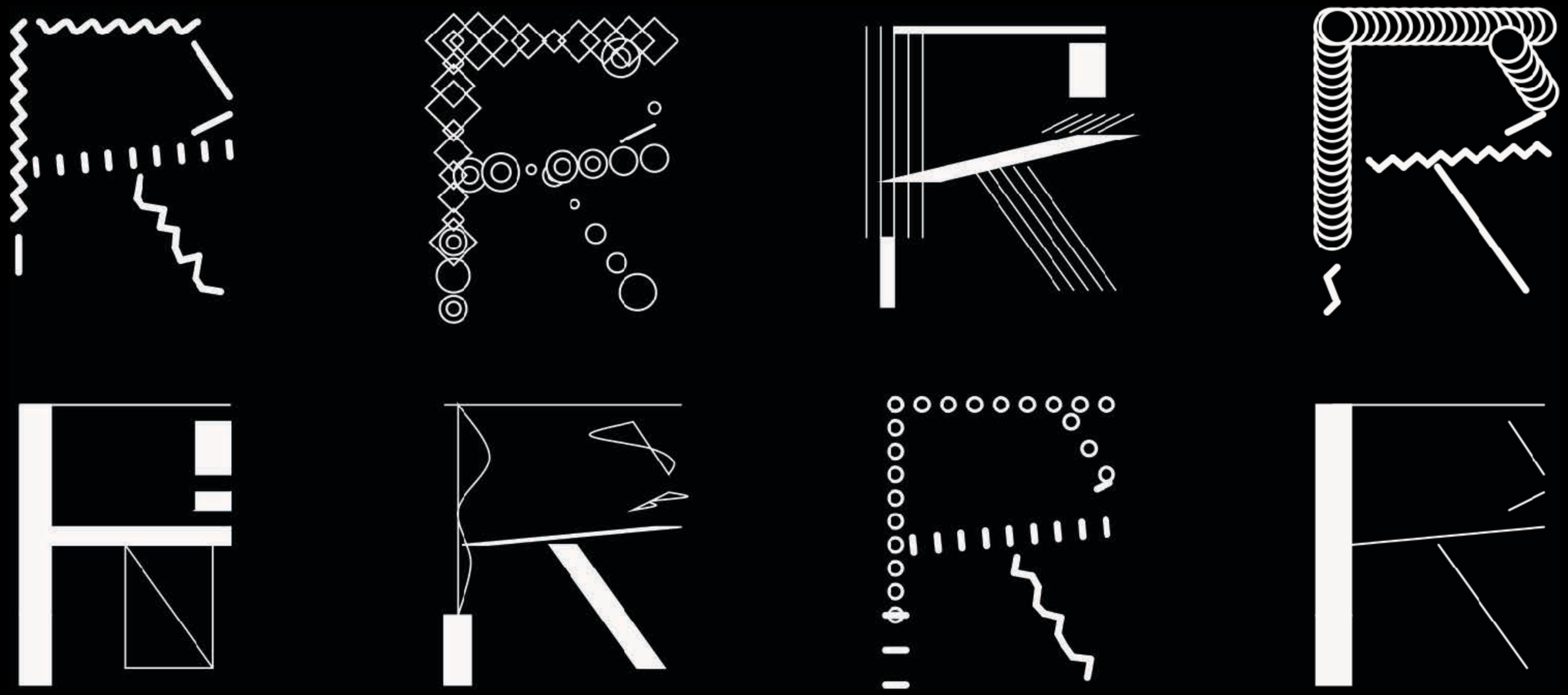
Alternatives
1 2 3 4

See
Glyphs Text Stats

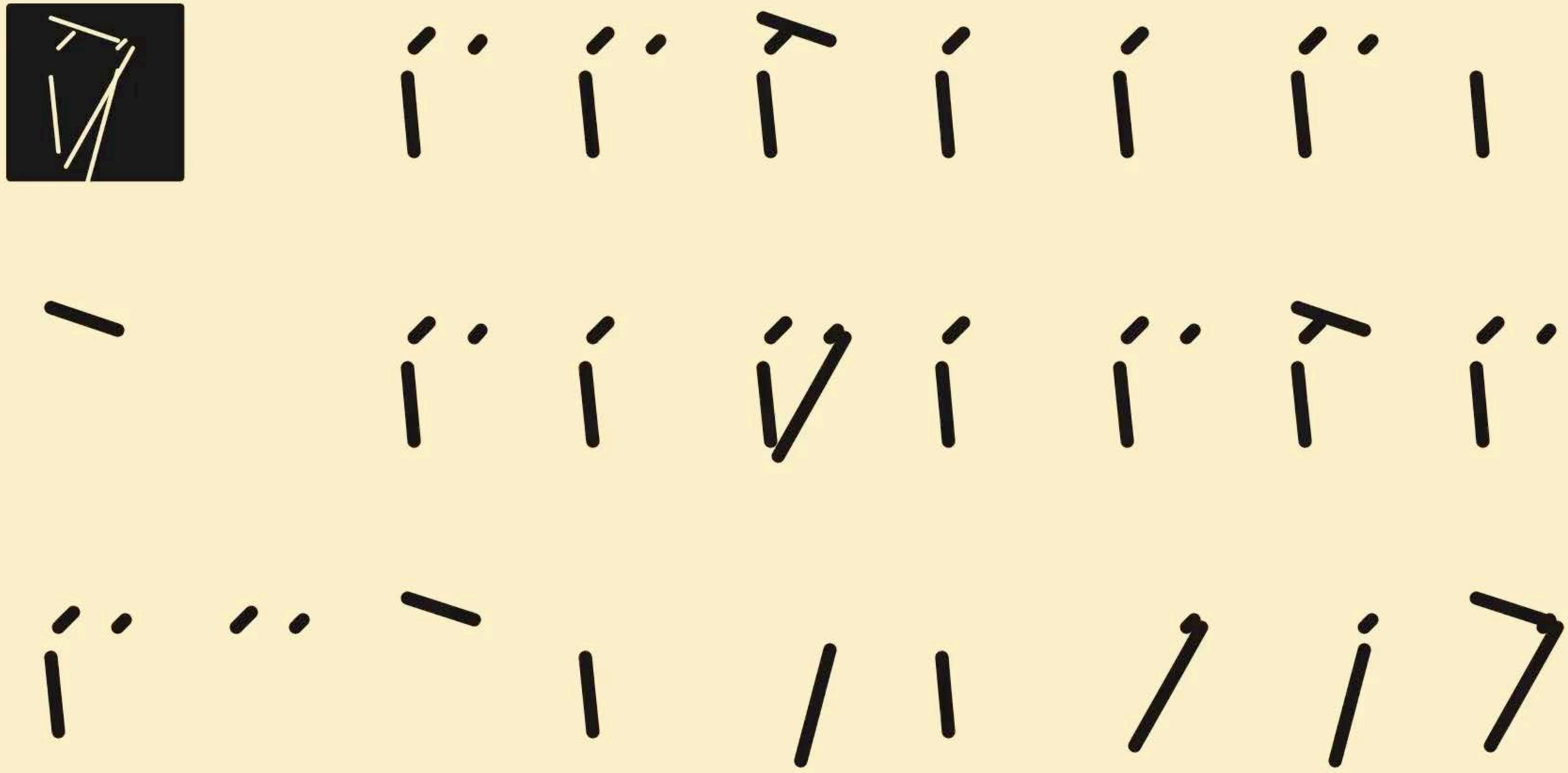
Export
Stencil Video



Screenshots of Processing sketches to generate shapes that replace the stencils' elements



Elements of a stencil replaced with different shapes



NATURAL SELECTION IS A POWER INCESSANTLY READY FOR ACTION AND IS IMMEASURABLY SUPERIOR TO MANS FEEBLE EFFORTS
AS THE WORKS OF NATURE ARE TO THOSE OF ART IF IT COULD BE DEMONSTRATED THAT ANY COMPLEX ORGAN EXISTED WHICH
COULD NOT POSSIBLY HAVE BEEN FORMED BY NUMEROUS SUCCESSIVE SLIGHT MODIFICATIONS MY THEORY WOULD ABSOLUTELY
BREAK DOWN BUT I CAN FIND NO SUCH CASE MAN SELECTS ONLY FOR HIS OWN GOOD NATURE ONLY FOR THAT OF THE BEING WHICH
SHE TENDS ONE GENERAL LAW LEADING TO THE ADVANCEMENT OF ALL ORGANIC BEINGS NAMELY MULTIPLY VARY LET THE
STRONGEST LIVE AND THE WEAKEST DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING THE THINGS
THEY NEED TO SURVIVE NATURAL SELECTION IS A POWER INCESSANTLY READY FOR ACTION AND IS IMMEASURABLY SUPERIOR TO
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VARY LET THE STRONGEST LIVE AND THE WEAKEST DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING
THE THINGS THEY NEED TO SURVIVE NATURAL SELECTION IS A POWER INCESSANTLY READY FOR ACTION AND IS IMMEASURABLY
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MODIFICATIONS MY THEORY WOULD ABSOLUTELY BREAK DOWN BUT I CAN FIND NO SUCH CASE MAN SELECTS ONLY FOR HIS OWN
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BEINGS NAMELY MULTIPLY VARY LET THE STRONGEST LIVE AND THE WEAKEST DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A
SPECIES BECAME AT DOING THE THINGS THEY NEED TO SURVIVE NATURAL SELECTION IS A POWER INCESSANTLY READY FOR
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IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING THE THINGS THEY NEED TO SURVIVE NATURAL SELECTION IS A POWER
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TO THOSE OF ART IF IT COULD BE DEMONSTRATED THAT ANY COMPLEX ORGAN EXISTED WHICH COULD NOT POSSIBLY HAVE BEEN
FORMED BY NUMEROUS SUCCESSIVE SLIGHT MODIFICATIONS MY THEORY WOULD ABSOLUTELY BREAK DOWN BUT I CAN FIND NO
SUCH CASE MAN SELECTS ONLY FOR HIS OWN GOOD NATURE ONLY FOR THAT OF THE BEING WHICH SHE TENDS ONE GENERAL LAW
LEADING TO THE ADVANCEMENT OF ALL ORGANIC BEINGS NAMELY MULTIPLY VARY LET THE STRONGEST LIVE AND THE WEAKEST
DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING THE THINGS THEY NEED TO SURVIVE NATURAL
SELECTION IS A POWER INCESSANTLY READY FOR ACTION AND IS IMMEASURABLY SUPERIOR TO MANS FEEBLE EFFORTS AS THE
WORKS OF NATURE ARE TO THOSE OF ART IF IT COULD BE DEMONSTRATED THAT ANY COMPLEX ORGAN EXISTED WHICH COULD NOT
POSSIBLY HAVE BEEN FORMED BY NUMEROUS SUCCESSIVE SLIGHT MODIFICATIONS MY THEORY WOULD ABSOLUTELY BREAK DOWN
BUT I CAN FIND NO SUCH CASE MAN SELECTS ONLY FOR HIS OWN GOOD NATURE ONLY FOR THAT OF THE BEING WHICH SHE TENDS
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AND THE WEAKEST DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING THE THINGS THEY NEED TO
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BEING WHICH SHE TENDS ONE GENERAL LAW LEADING TO THE ADVANCEMENT OF ALL ORGANIC BEINGS NAMELY MULTIPLY VARY LET
THE STRONGEST LIVE AND THE WEAKEST DIE INTELLIGENCE IS BASED ON HOW EFFICIENT A SPECIES BECAME AT DOING THE
THINGS THEY NEED TO SURVIVE NATURAL SELECTION IS A POWER INCESSANTLY READY FOR ACTION AND IS IMMEASURABLY
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Generating
letters

Generating
faces

Generating
coins

Co-authored with João Correia,
Ernesto Costa, and Penousal Machado

Generating
letters

Generating
faces

Co-authored with João Correia,
Sérgio Rebelo, João Bicker,
and Penousal Machado

Generating
coins

Context

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- Computational face detection is widely used;

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- Face detection classifiers can have limitations;

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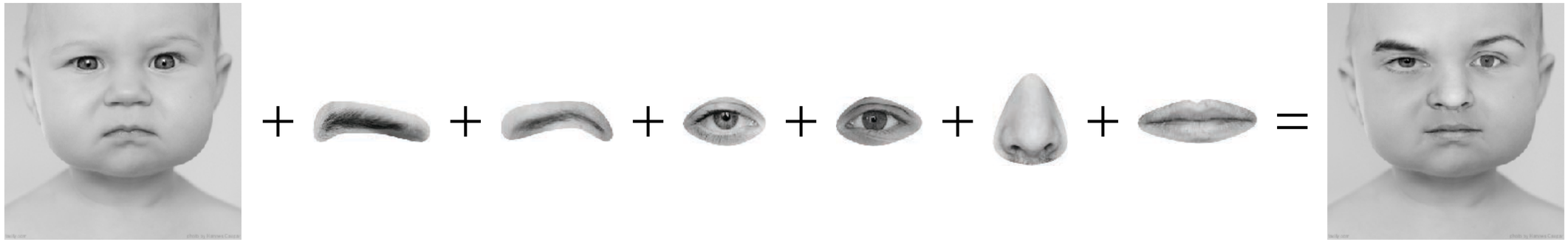
- Computational face detection is widely used;
- Face detection classifiers can have limitations;
- Opportunity to evolve face images that are not detected as such;
- Explore the borderline between the real and the artificial.



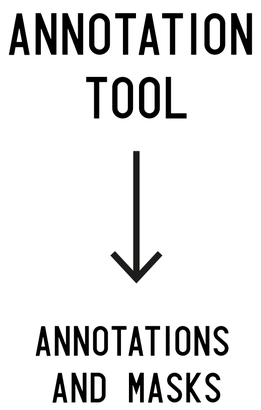
Process of generating a new face image
using the *X-Faces* system

Facial parts extracted from existing face images

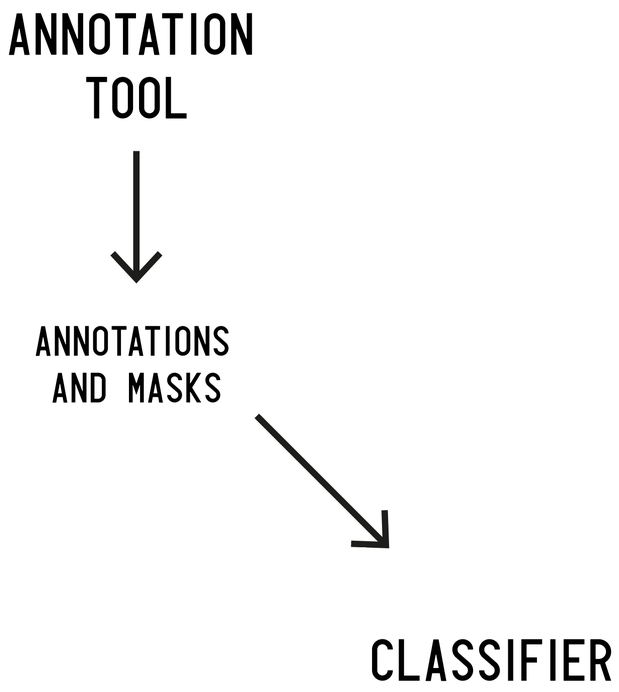
Two face images from an existing dataset and
two new face images generated from them

ANNOTATION TOOL

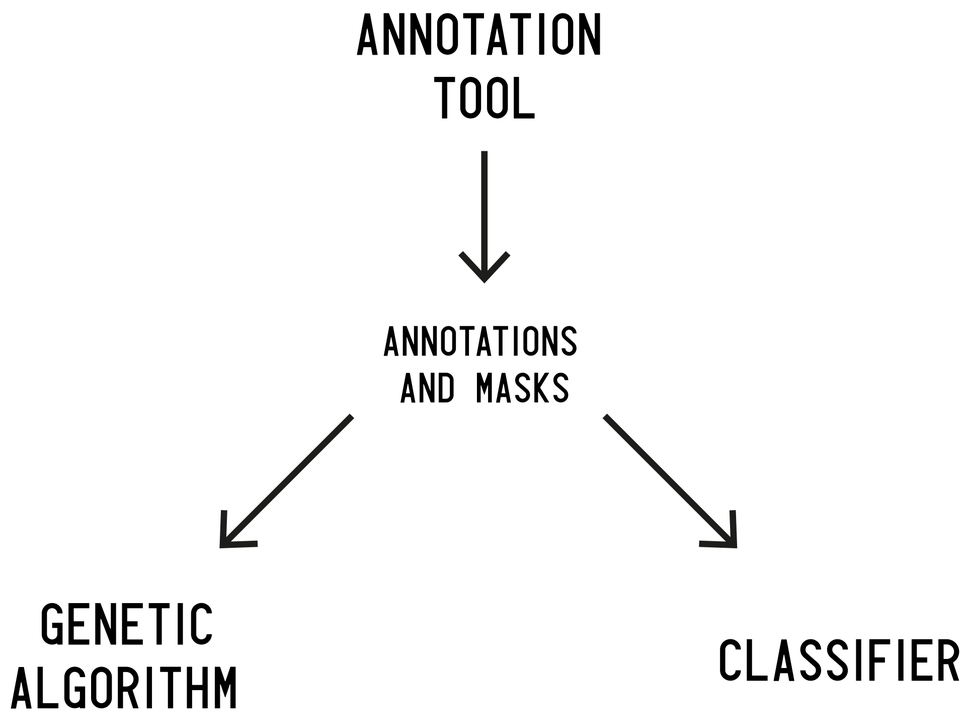
Overview of *X-Faces* system



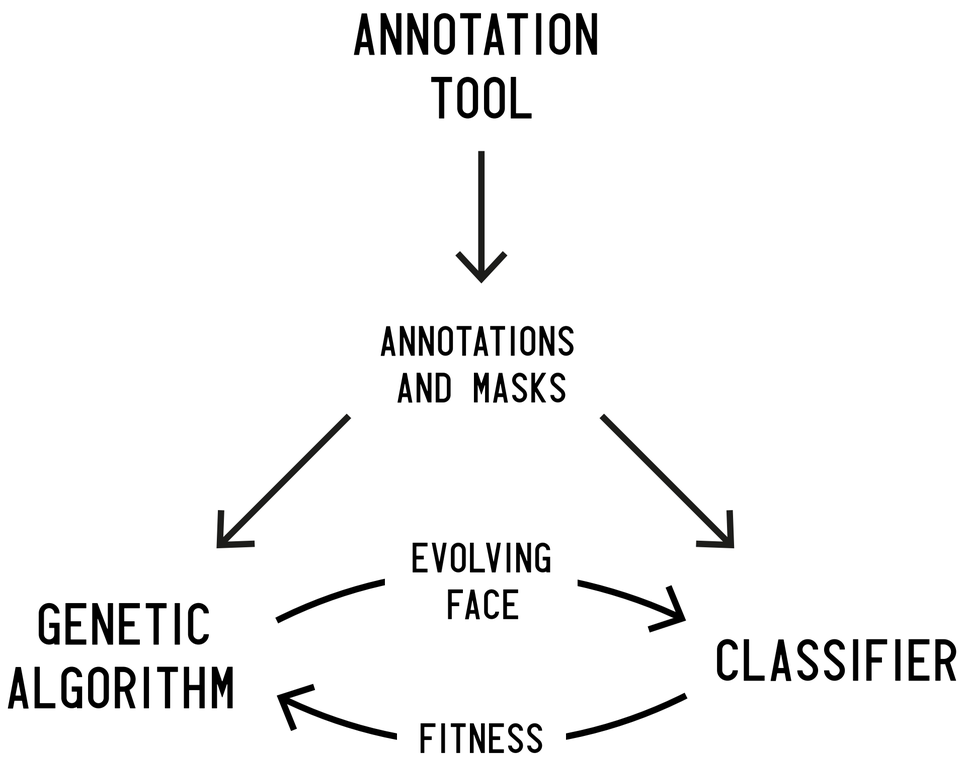
Overview of *X-Faces* system



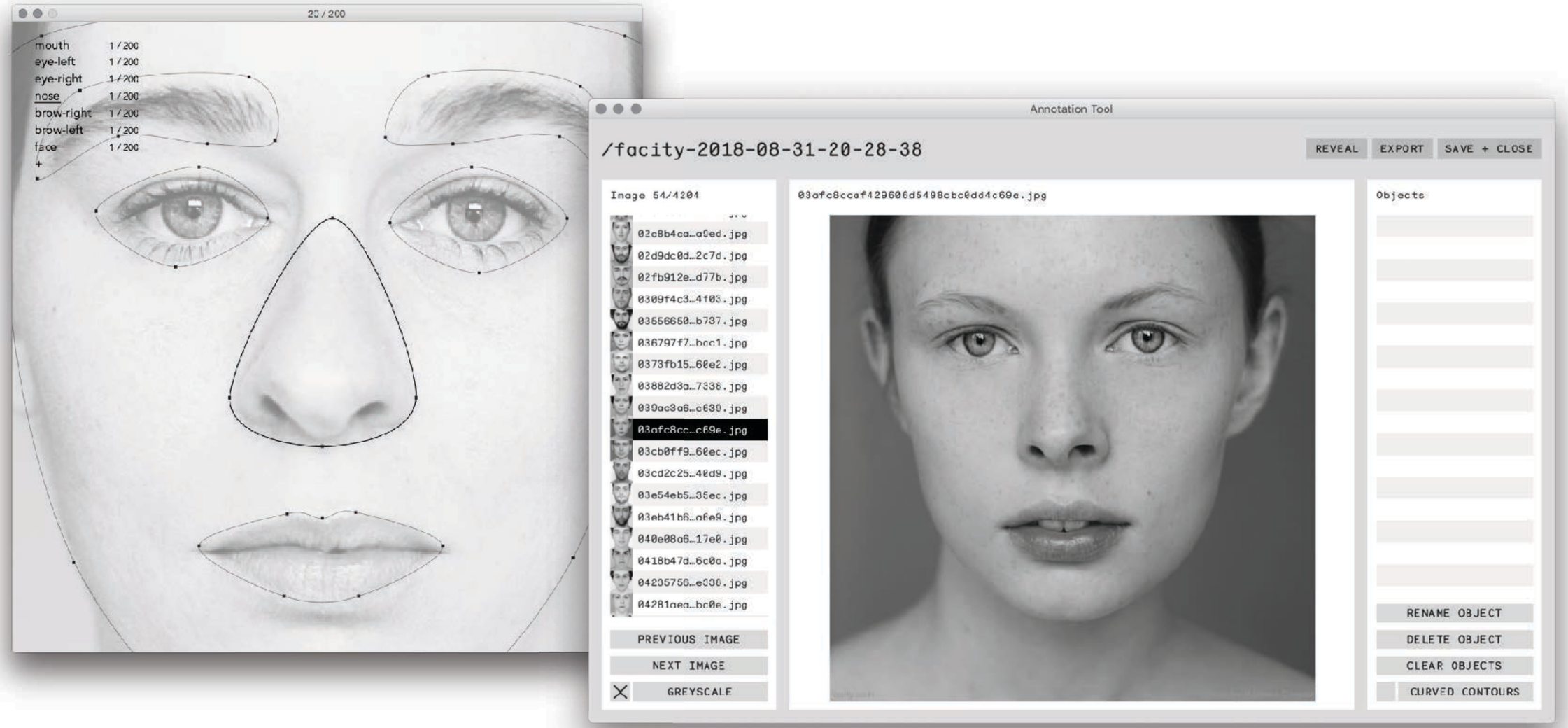
Overview of *X-Faces* system



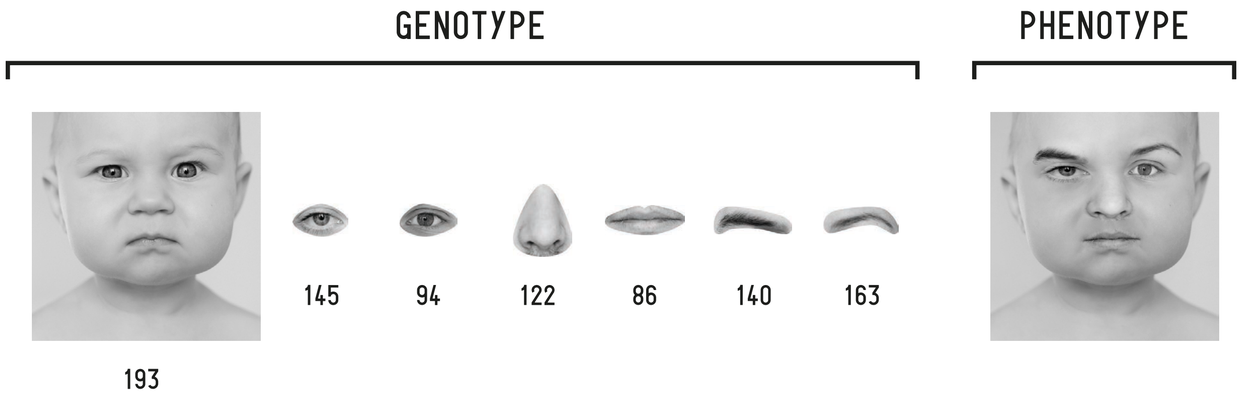
Overview of *X-Faces* system



Overview of *X-Faces* system



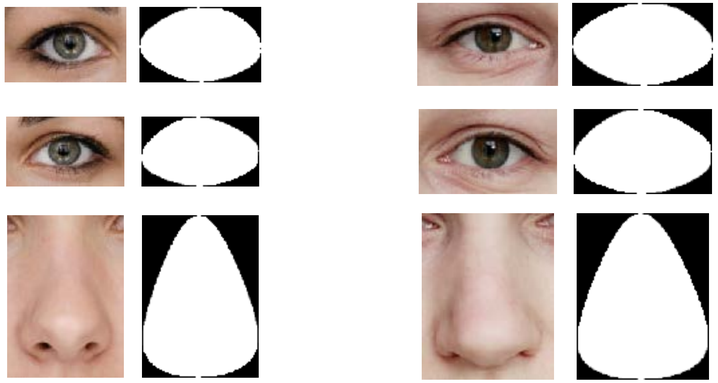
Screenshots of annotation tools
developed for *X-Faces*



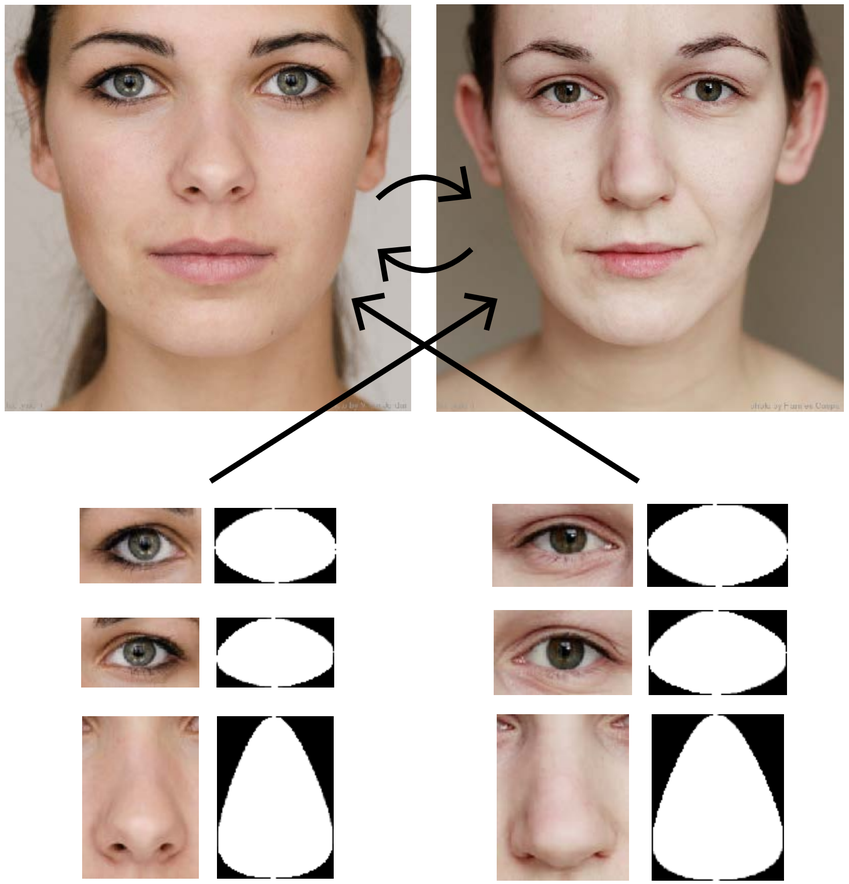
Encoding of evolving faces

Recombination of faces using the seamless clone algorithm by Pérez et al. (2003)

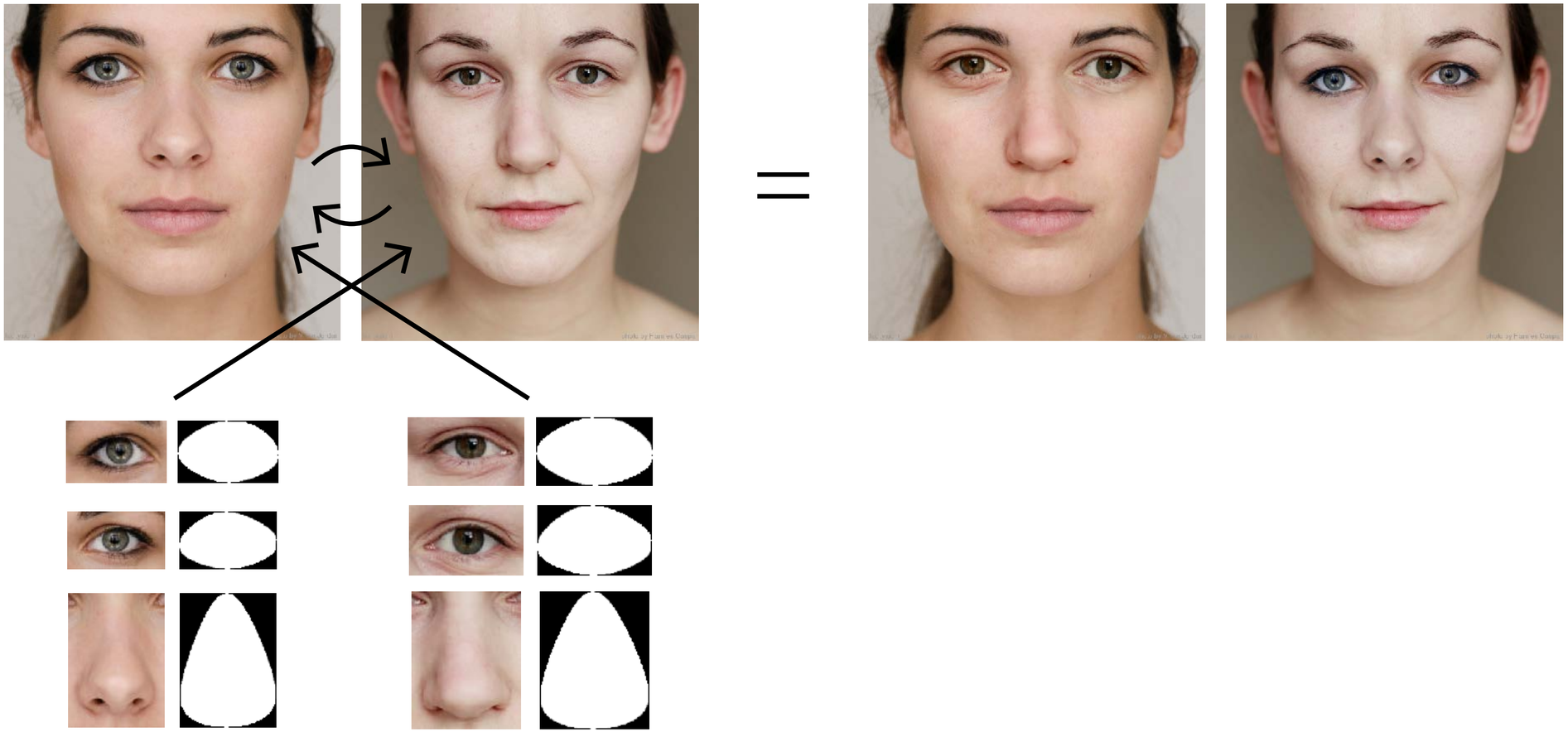
Recombination of faces using the seamless clone algorithm by Pérez et al. (2003)



Recombination of faces using the seamless clone algorithm by Pérez et al. (2003)



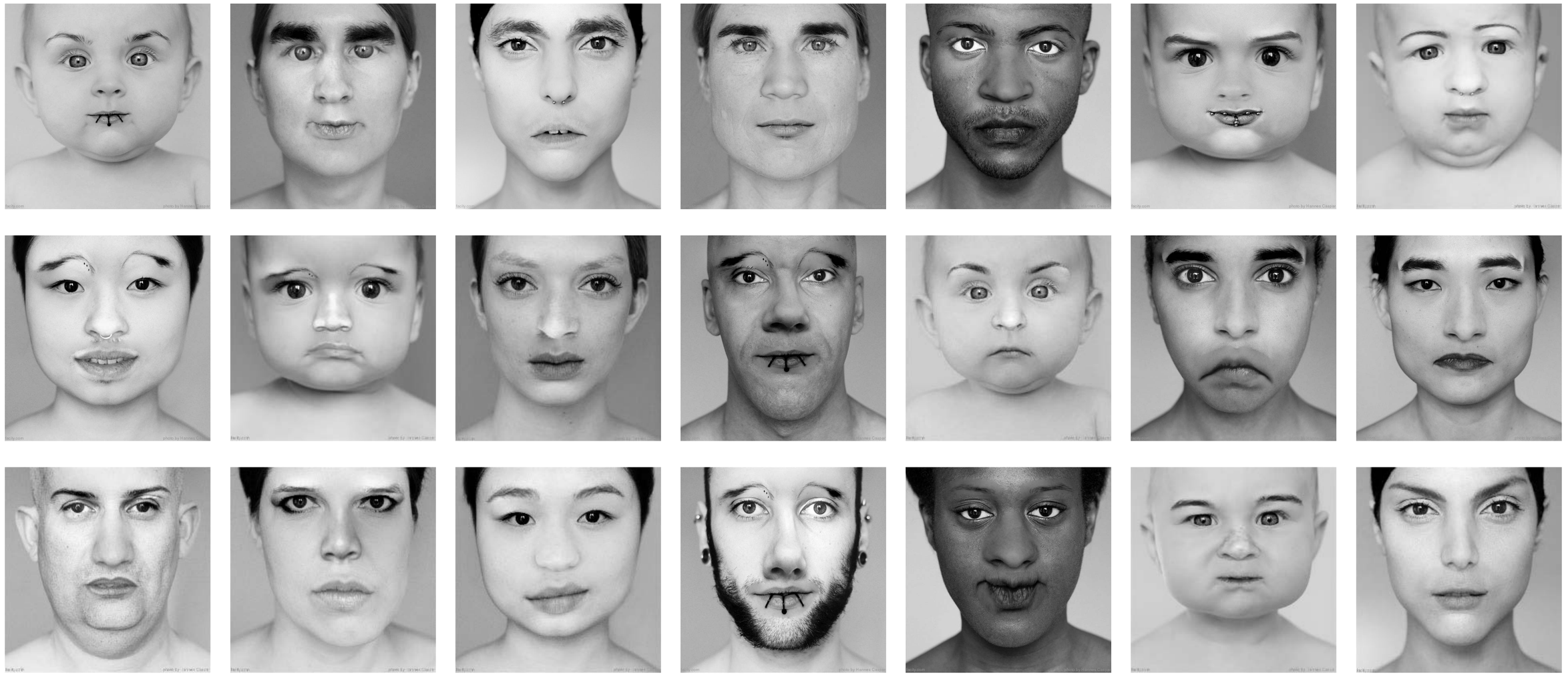
Recombination of faces using the seamless clone algorithm by Pérez et al. (2003)



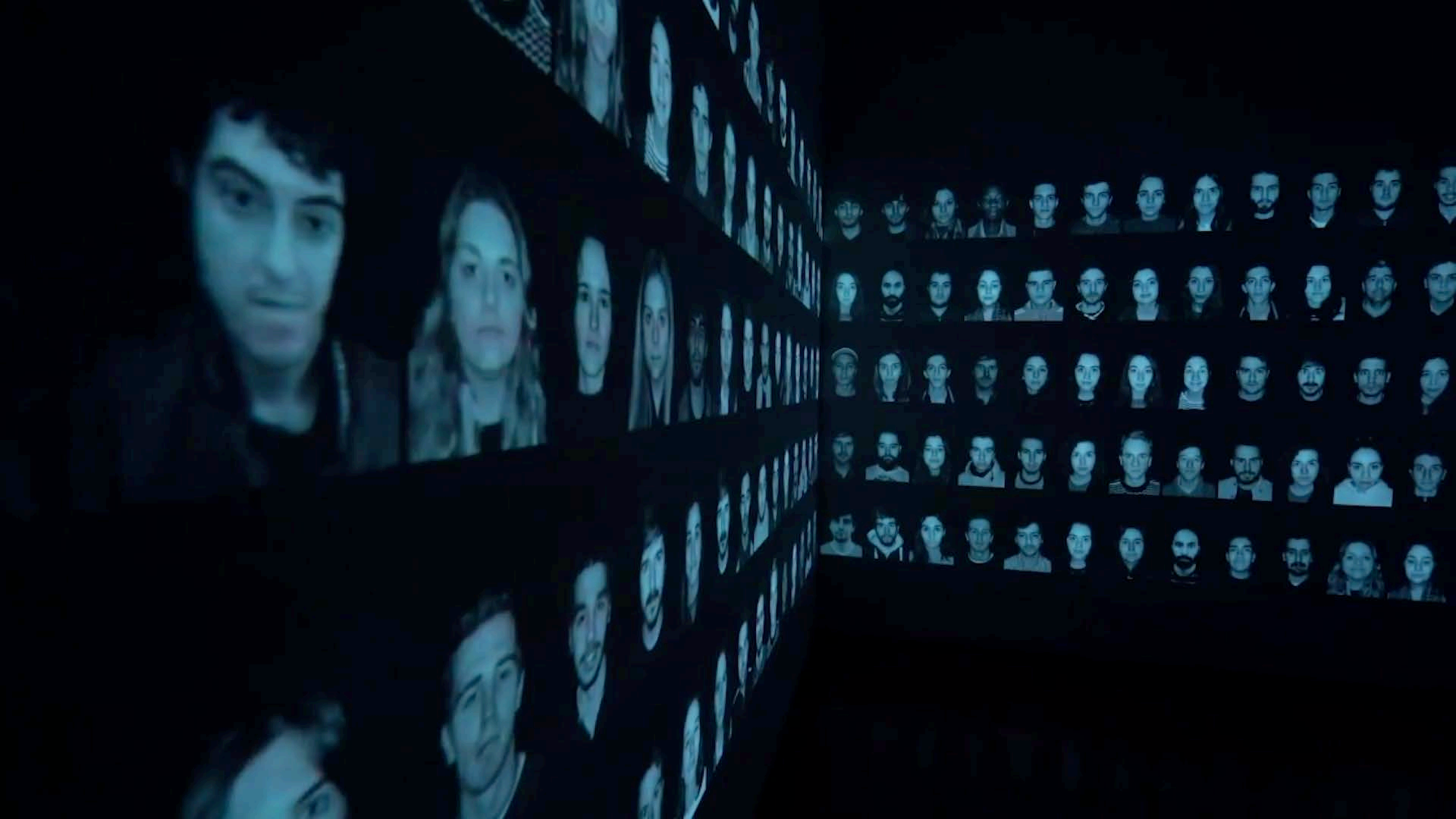
Recombination of faces using the seamless clone algorithm by Pérez et al. (2003)

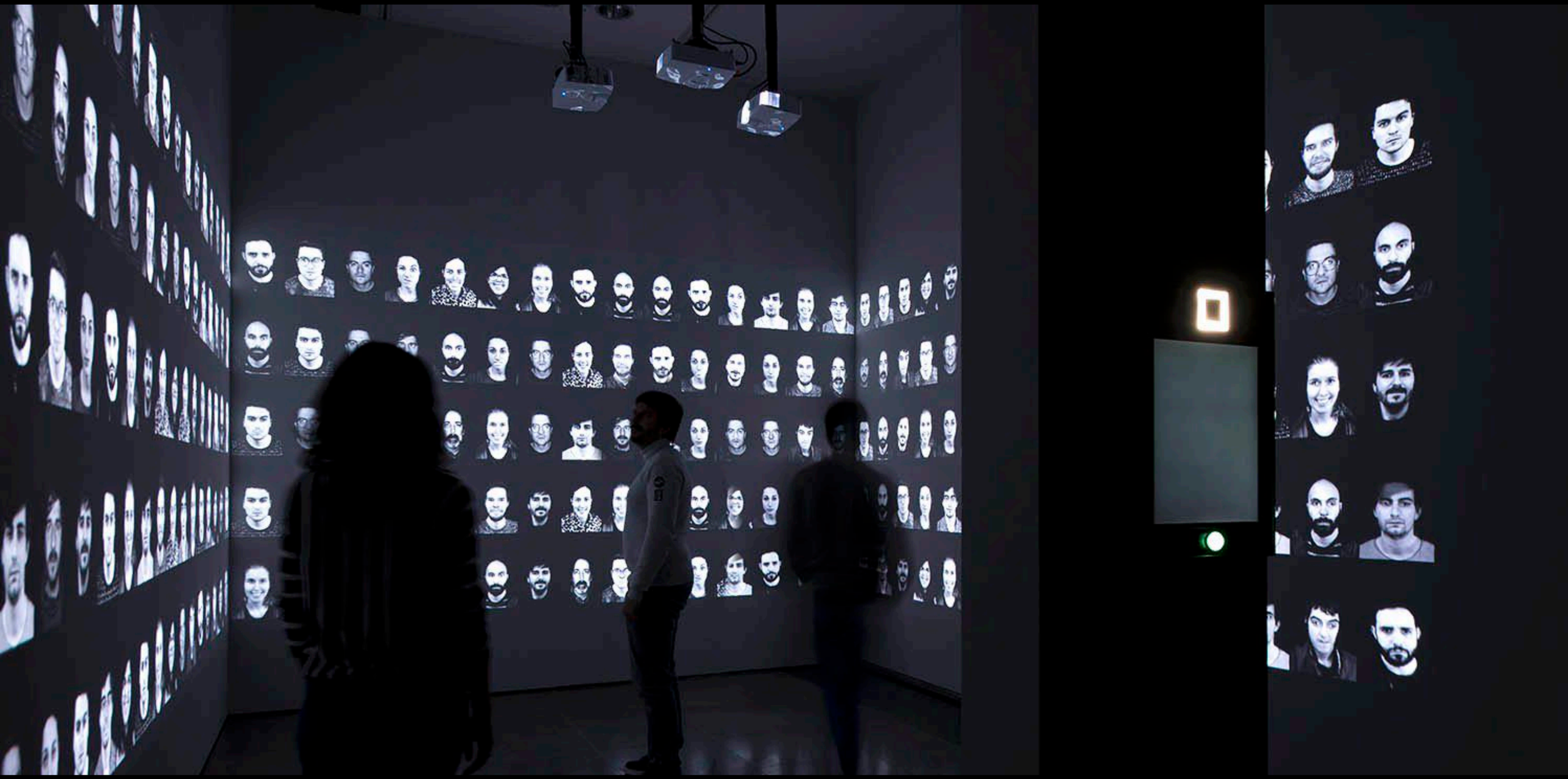
Different face parts on the same face

Different combinations



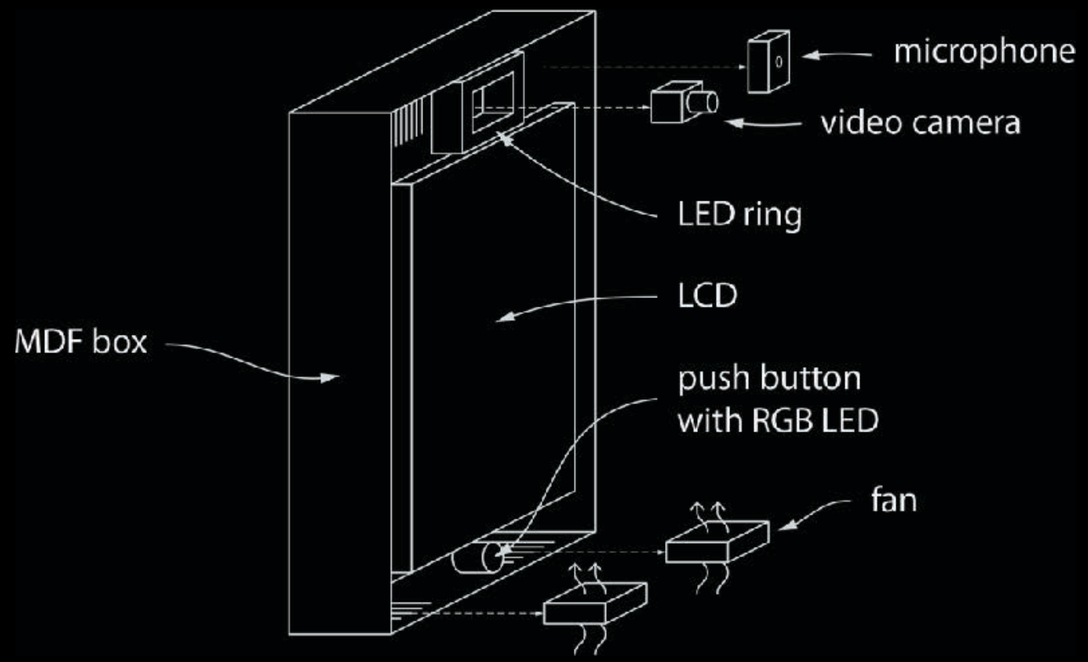
Examples of face images evolved
in different evolutionary runs

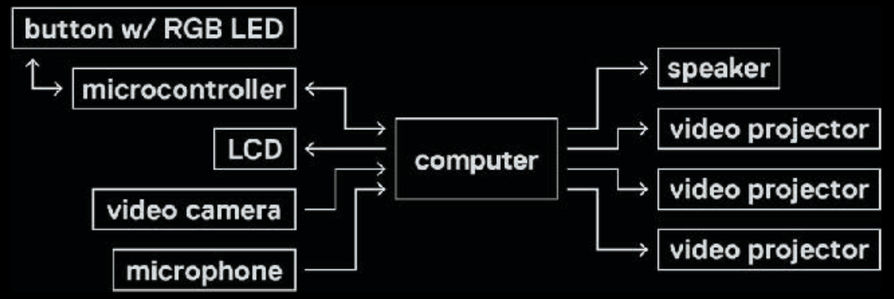




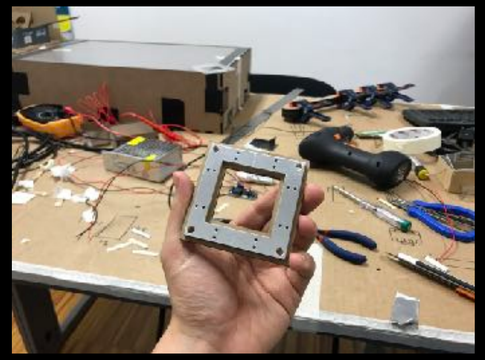
Portraits of No One installation

Interaction with the capturing box

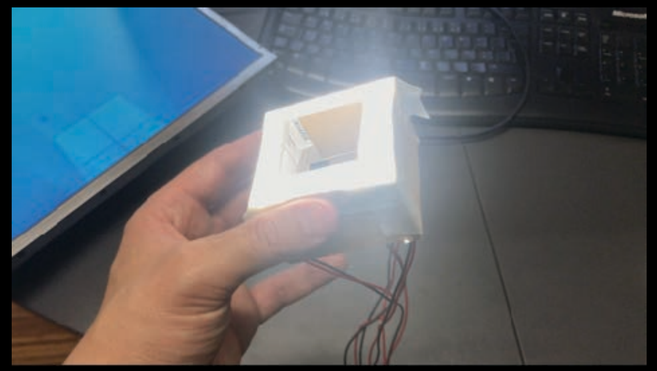
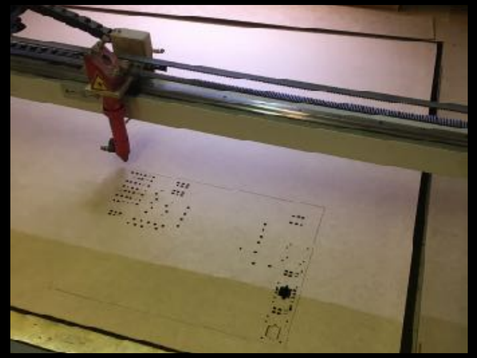
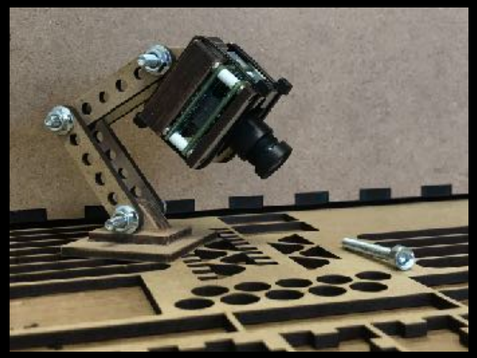




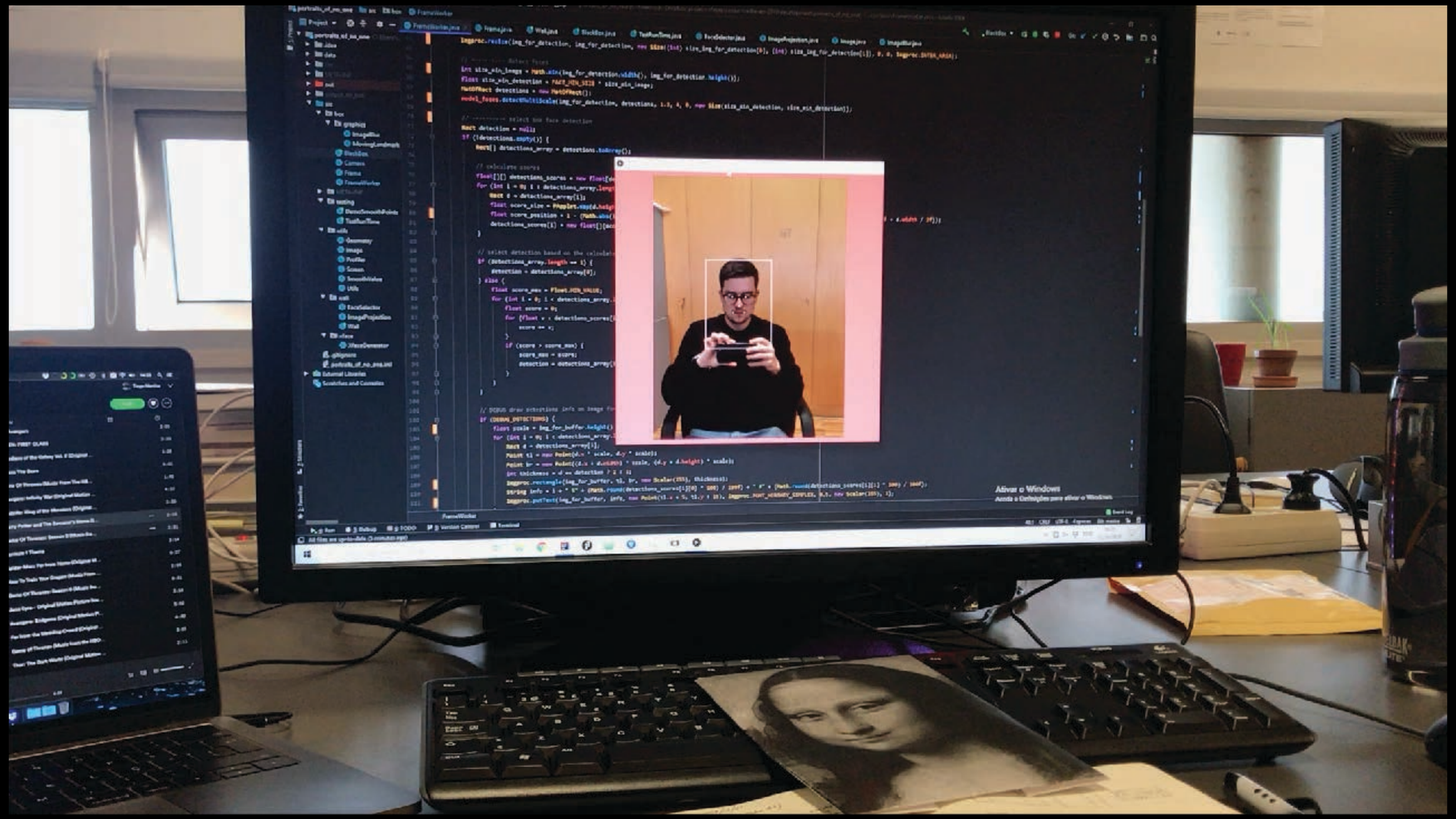
Installation hardware






Development process



Development process

Development process

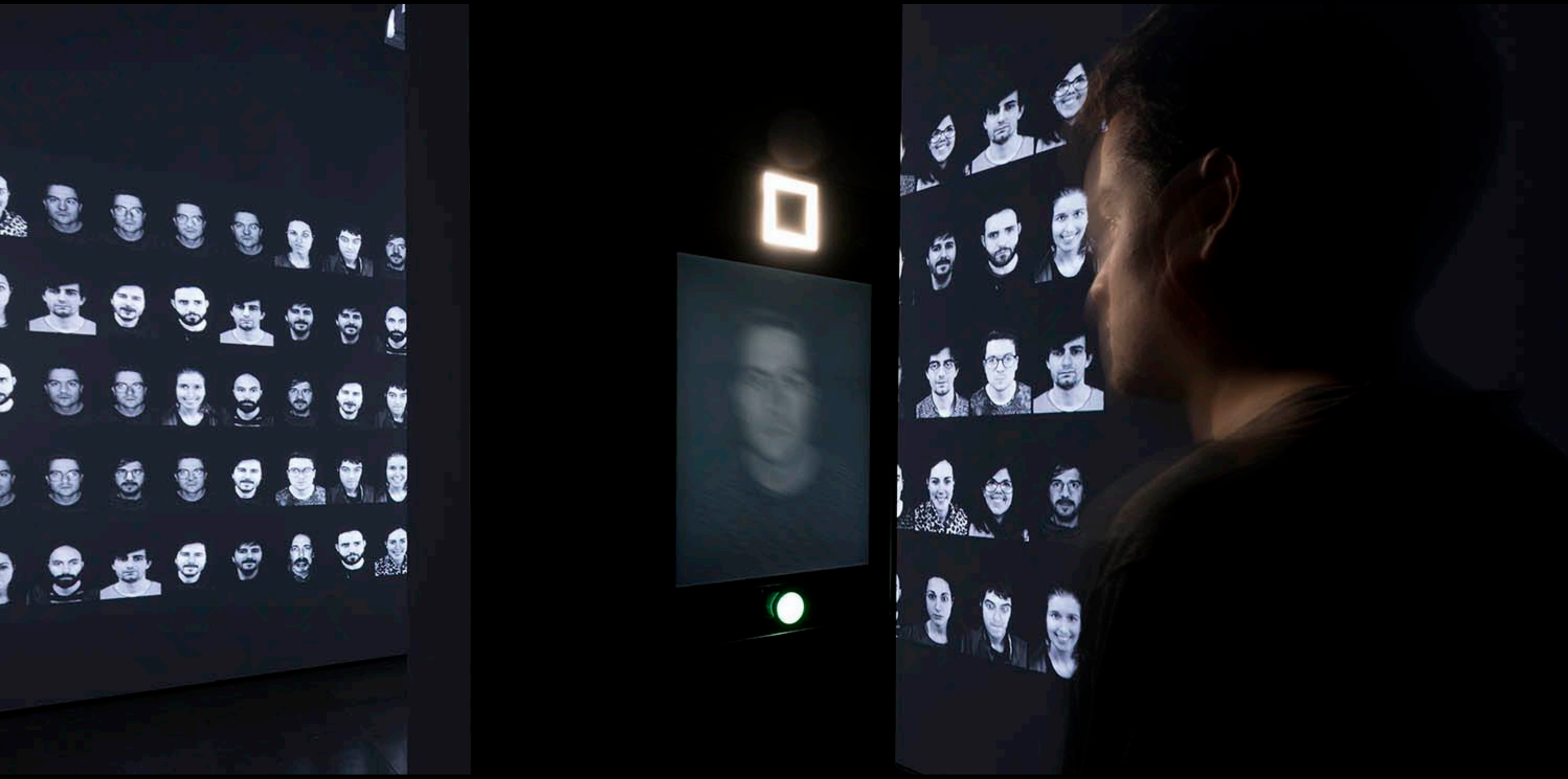
Faces images shown in Portraits of No One installation

Faces images shown in Portraits of No One installation

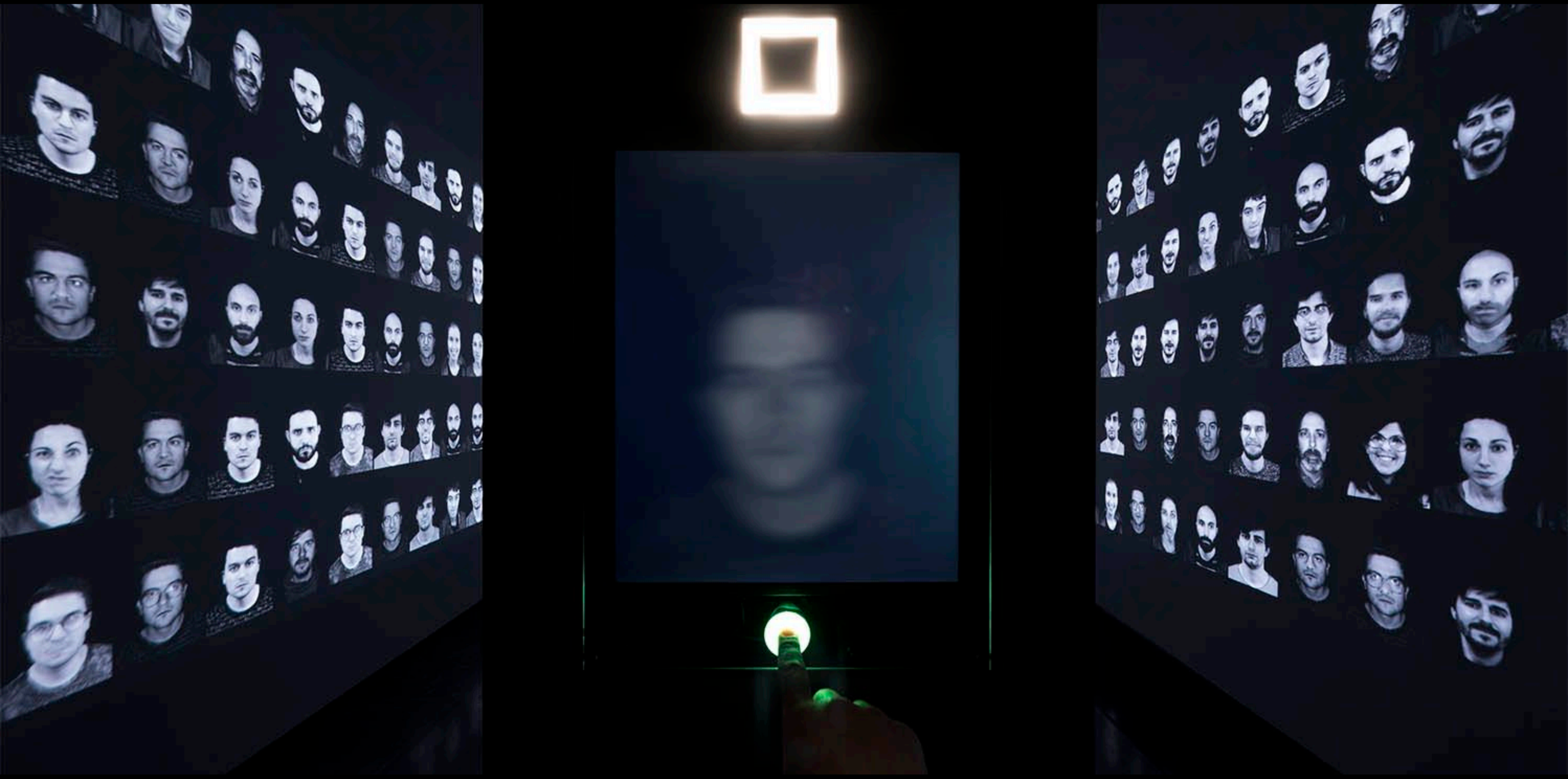
Portraits of No One installation

Portraits of No One installation

Portraits of No One installation



Portraits of No One installation



Portraits of No One installation

Installation *Portraits of No One* at Círculo de Artes Plásticas de Coimbra

Generating
letters

Generating
faces

Co-authored with João Correia,
Sérgio Rebelo, João Bicker,
and Penousal Machado

Generating
coins

Generating
letters

Generating
faces

Generating
coins

Co-authored with Amílcar Cardoso, Fábio Gouveia, João Bicker, João Correia, João Miguel Cunha, Luís Espírito Santo, Nuno Lourenço, Penousal Machado, and Sérgio M. Rebelo

Context

- National Press-Mint (INCM) invited us to create a coin designed by AI about the “digital world”.

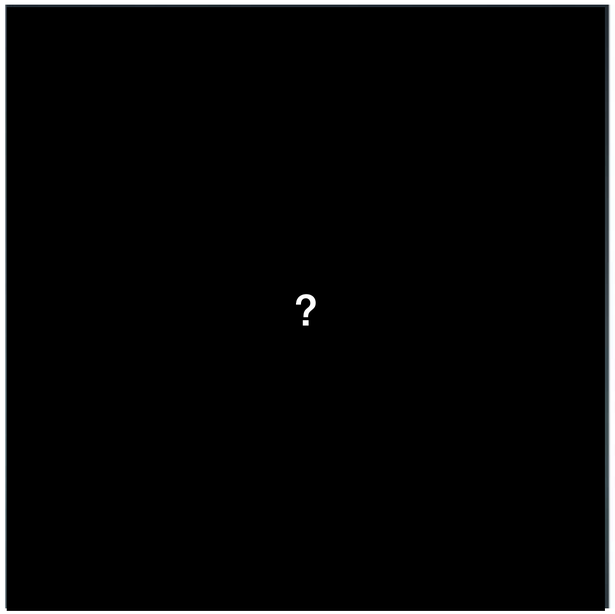
Context

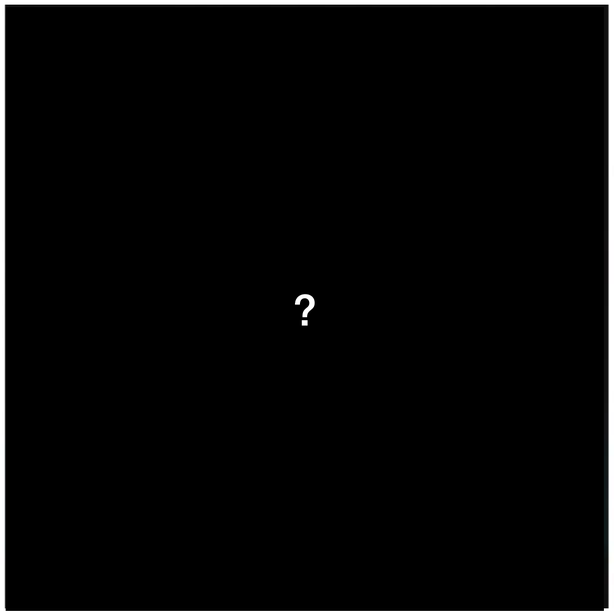
- National Press-Mint (INCM) invited us to create a coin designed by AI about the “digital world”.
- The goal is to mint this coin.

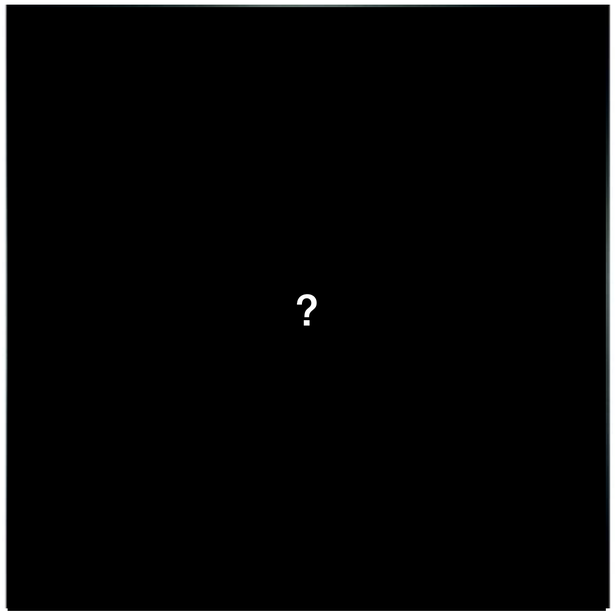
Design guidelines

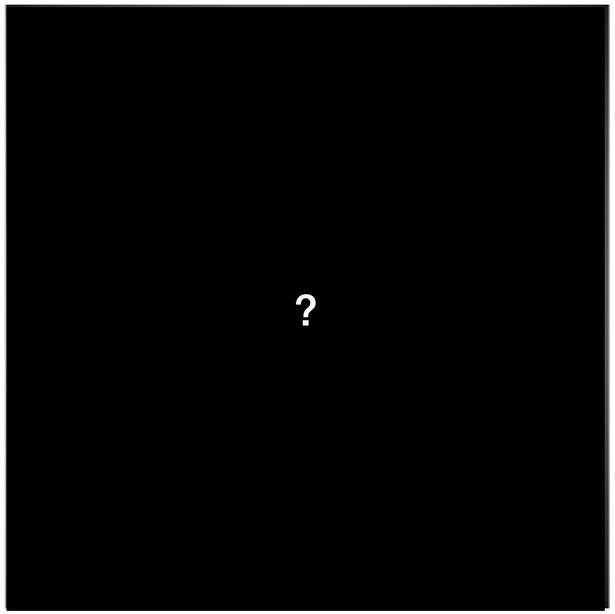
- The coin should be what AI considers to be a representation of a Portuguese coin about the “digital world.”

Prompt: A coin about the digital world designed by AI





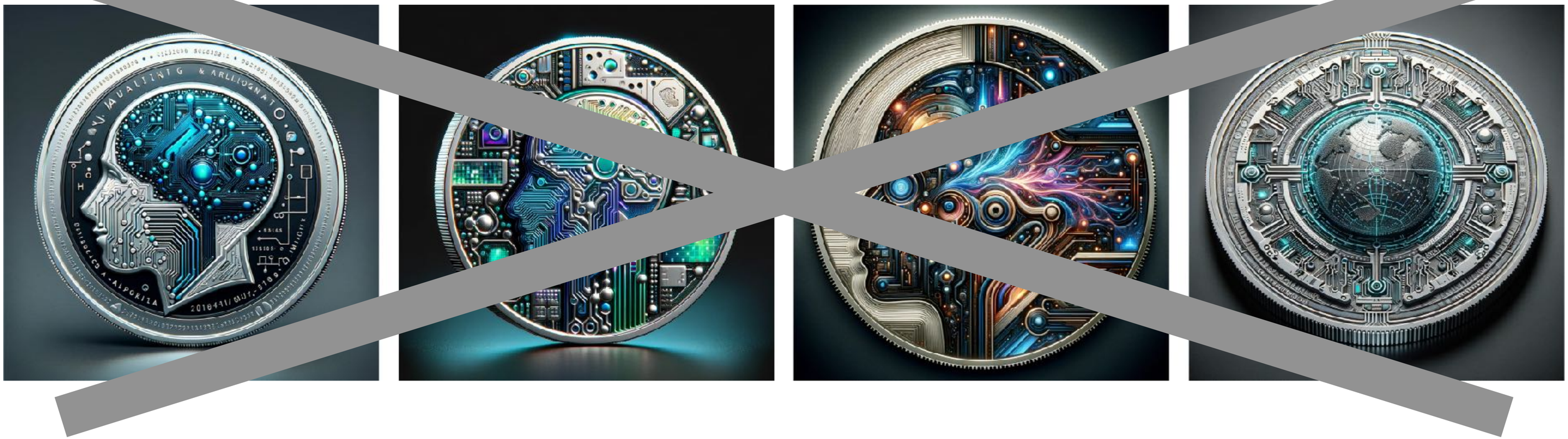




Prompt: A coin about the digital world designed by AI




Prompt: A coin about the digital world designed by AI



Design guidelines (cont.)

- The AI must be aligned with our view.

Design guidelines (cont.)

- The AI must be aligned with our view.
- The AI must be aligned with the collection of INCM.

Design guidelines (cont.)

- The AI must be aligned with our view.
- The AI must be aligned with the collection of INCM.
- The two coin faces should be connected.

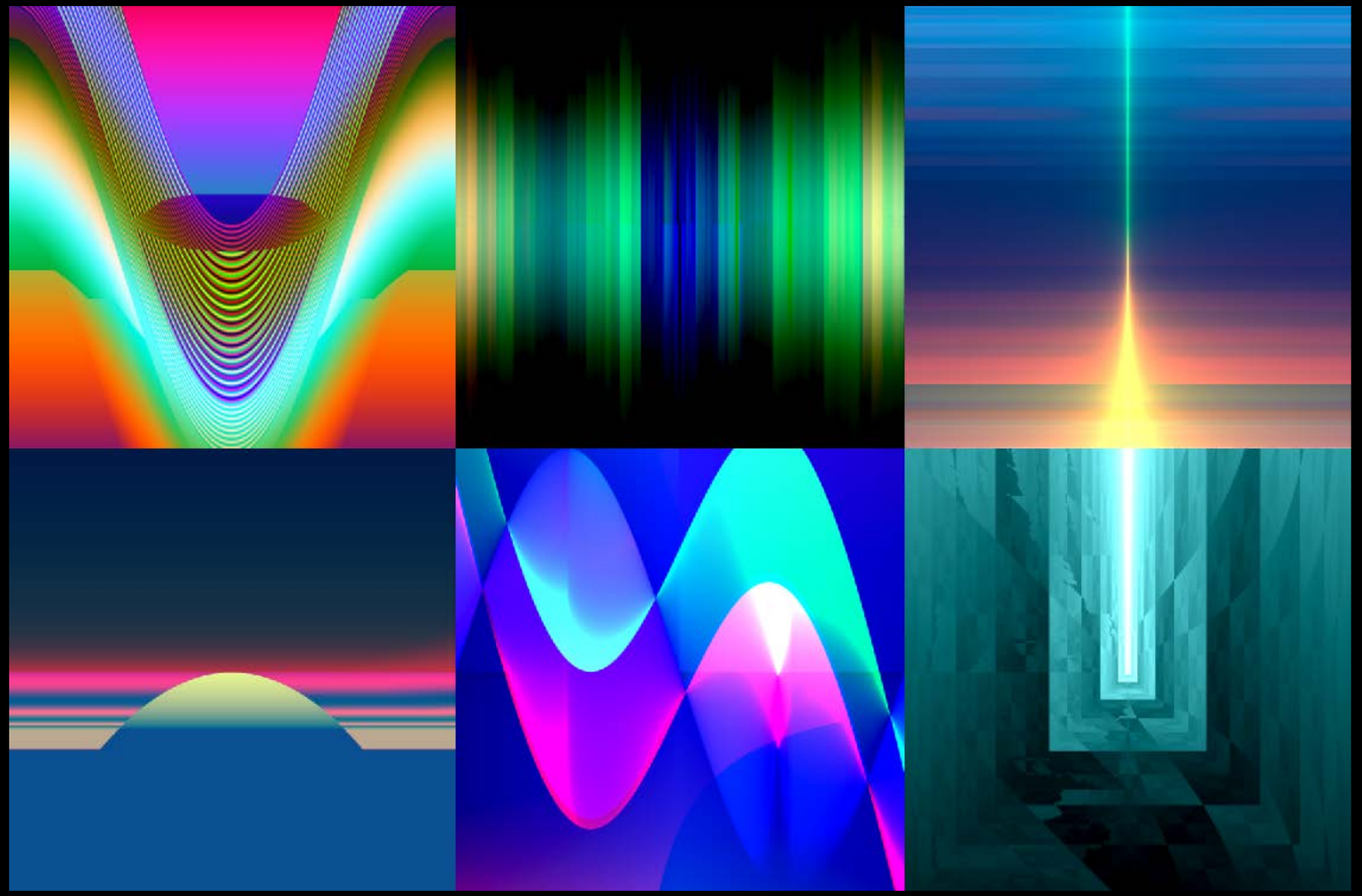
Concept

- One side is designed by AI for Humans and the other by Humans for AI.

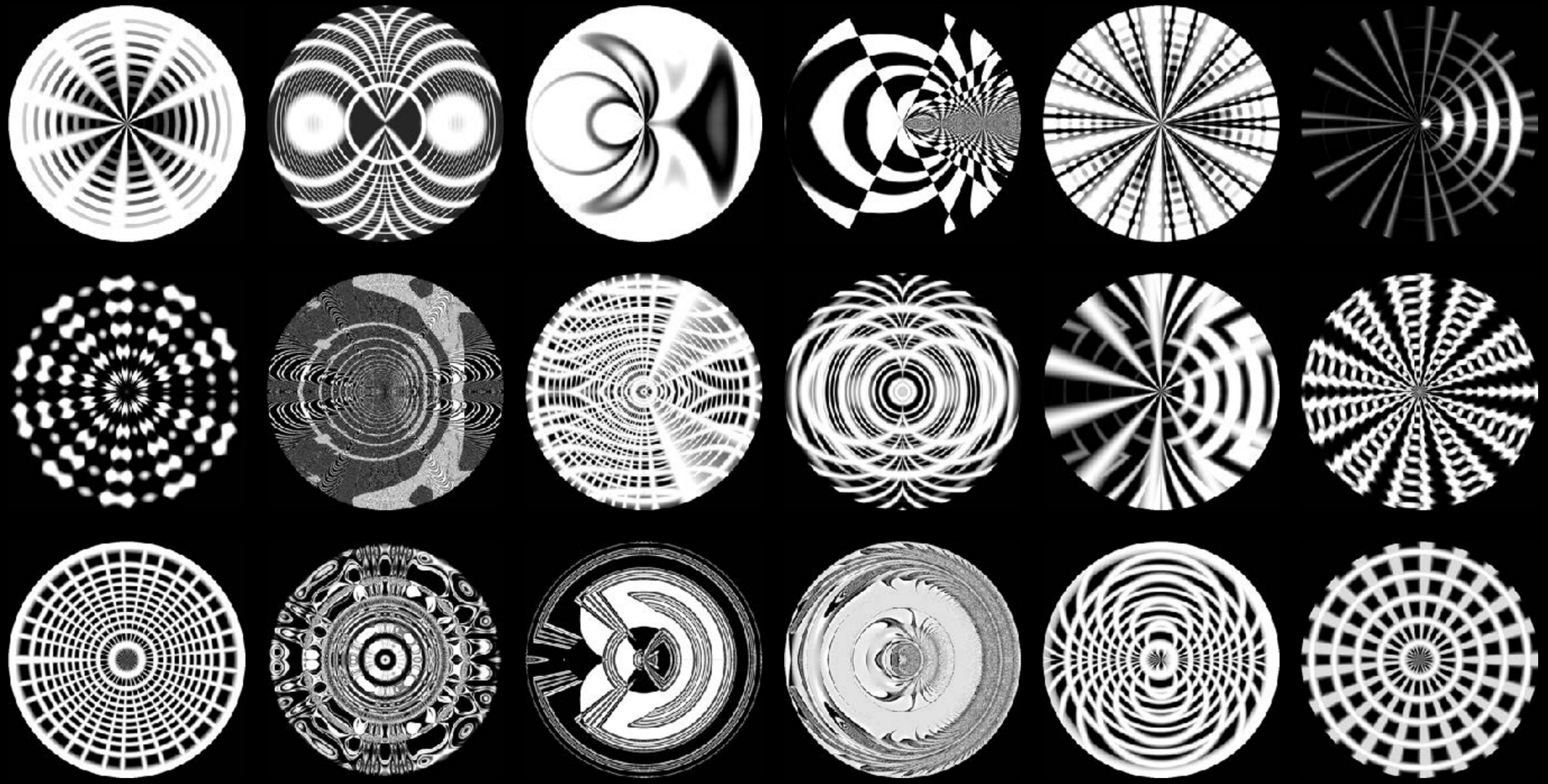
Concept

- One side is designed by AI for Humans and the other by Humans for AI.
- Both sides represent the same concept using a language adequate for the target audience (Humans or AI).

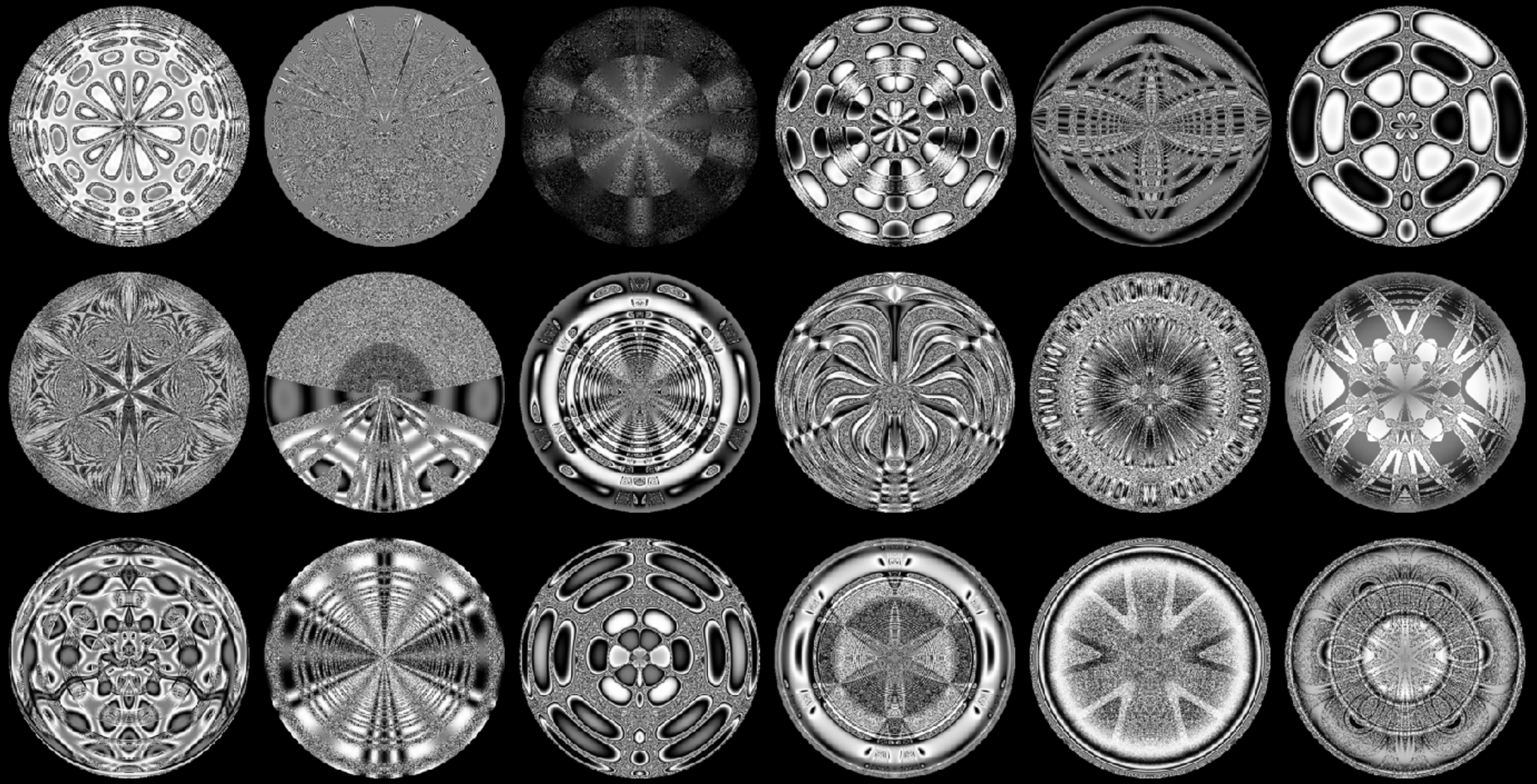
By AI for Humans



Examples of images generated with NEvAr+TensorGP



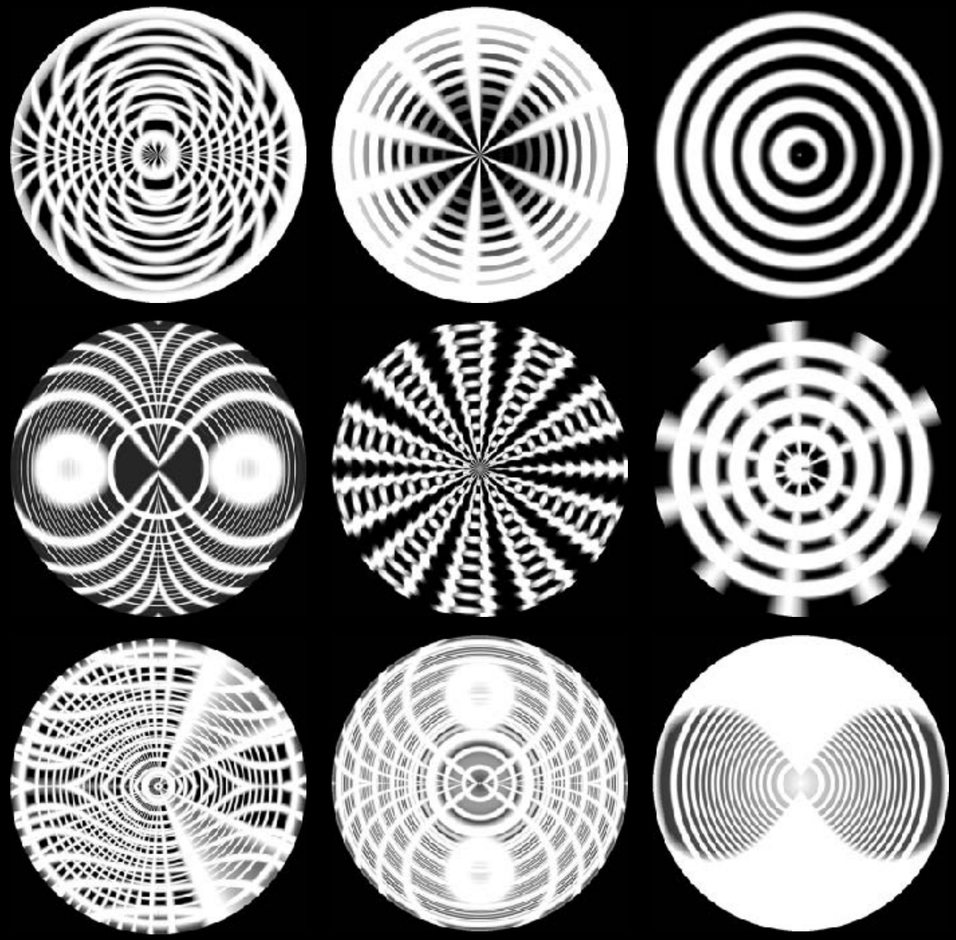
Images interactively generated with NEvAr+TensorGP using user-guided evolution



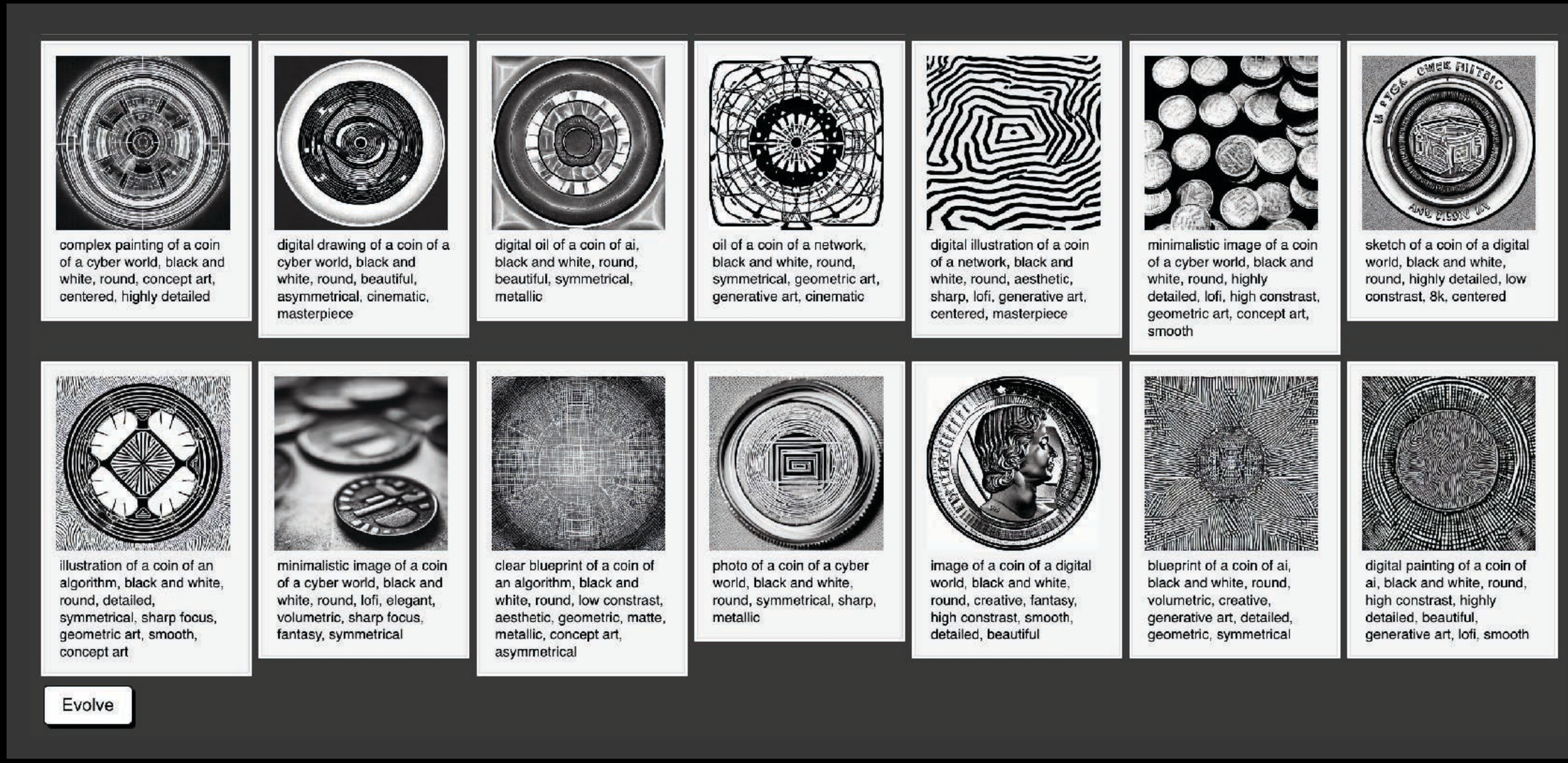
Images automatically generated with NEvAr+TensorGP using aesthetic models

Images of INCM coins

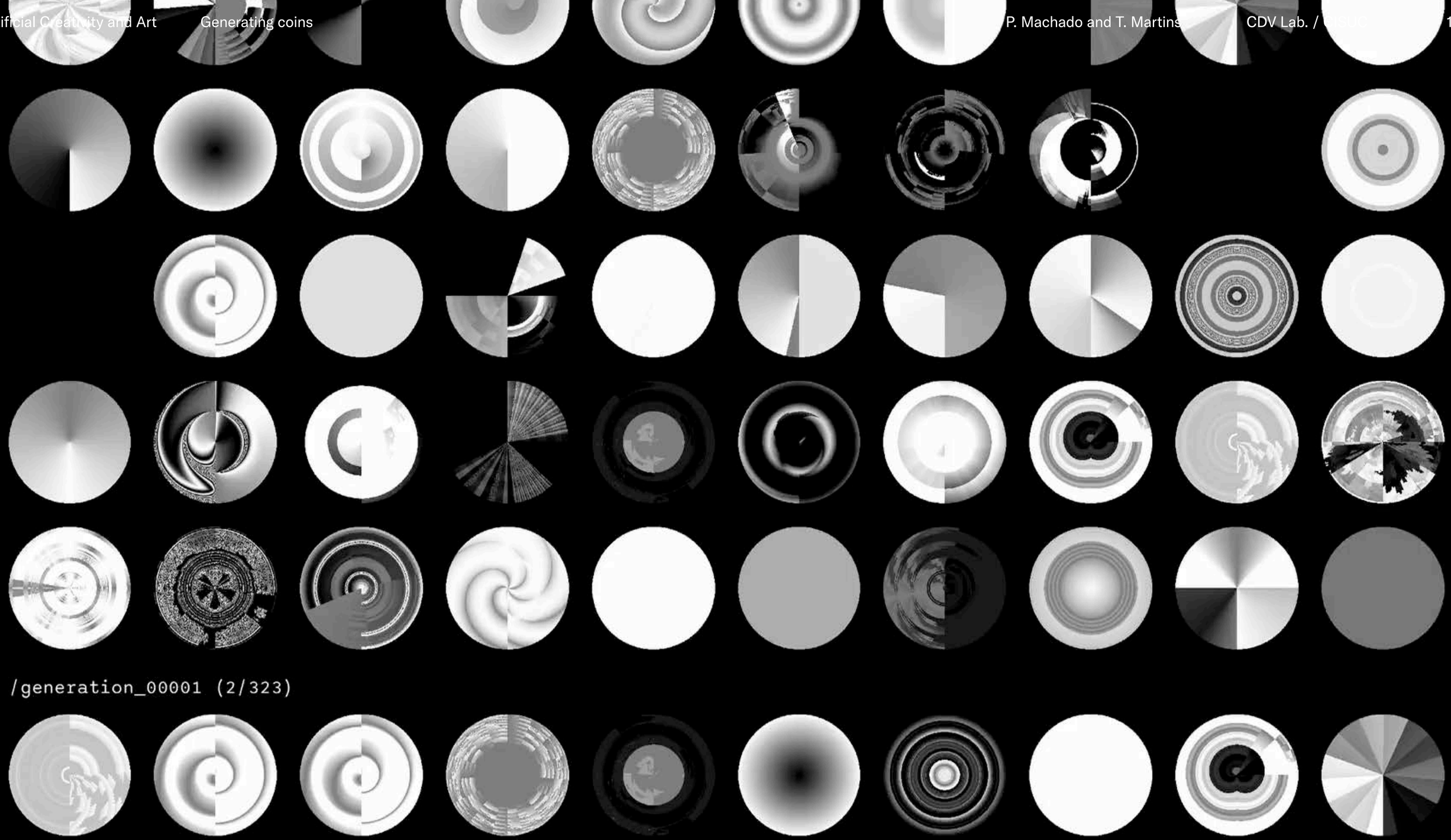
Images of INCM coins

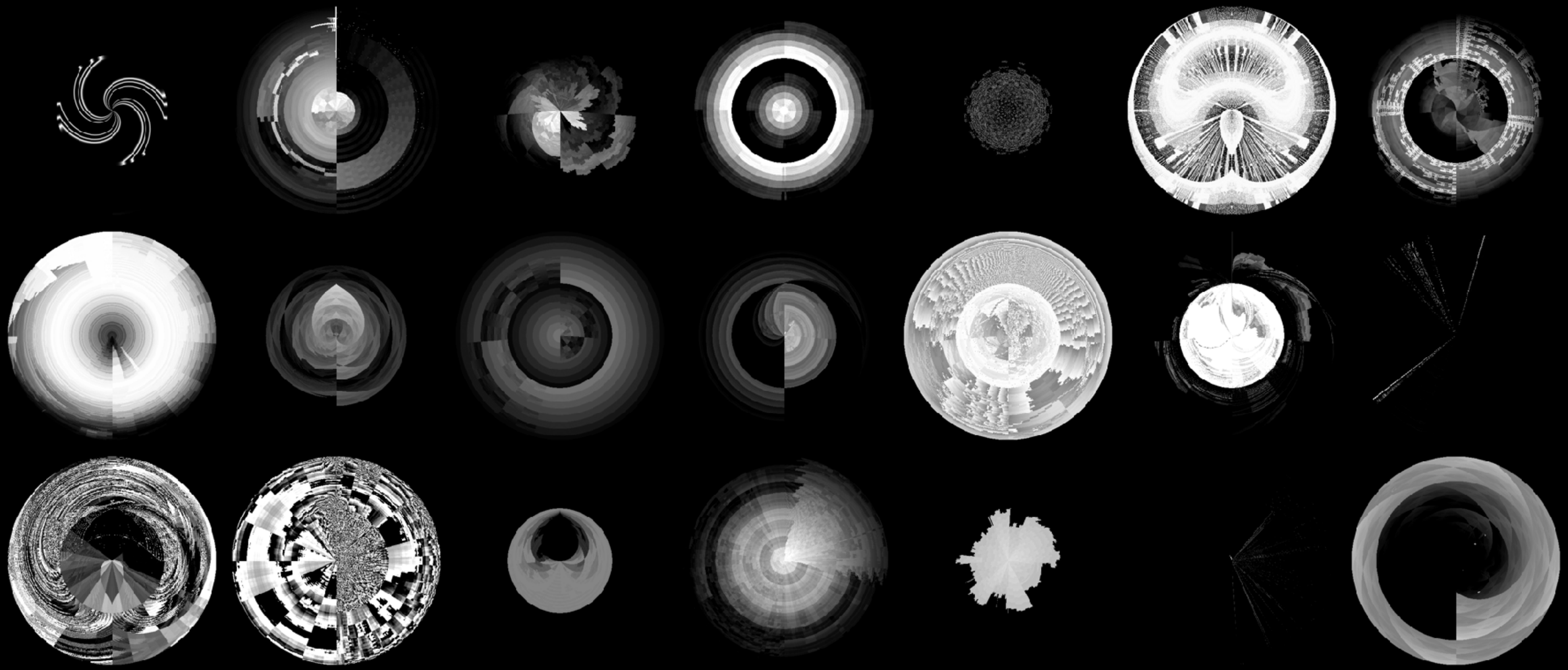


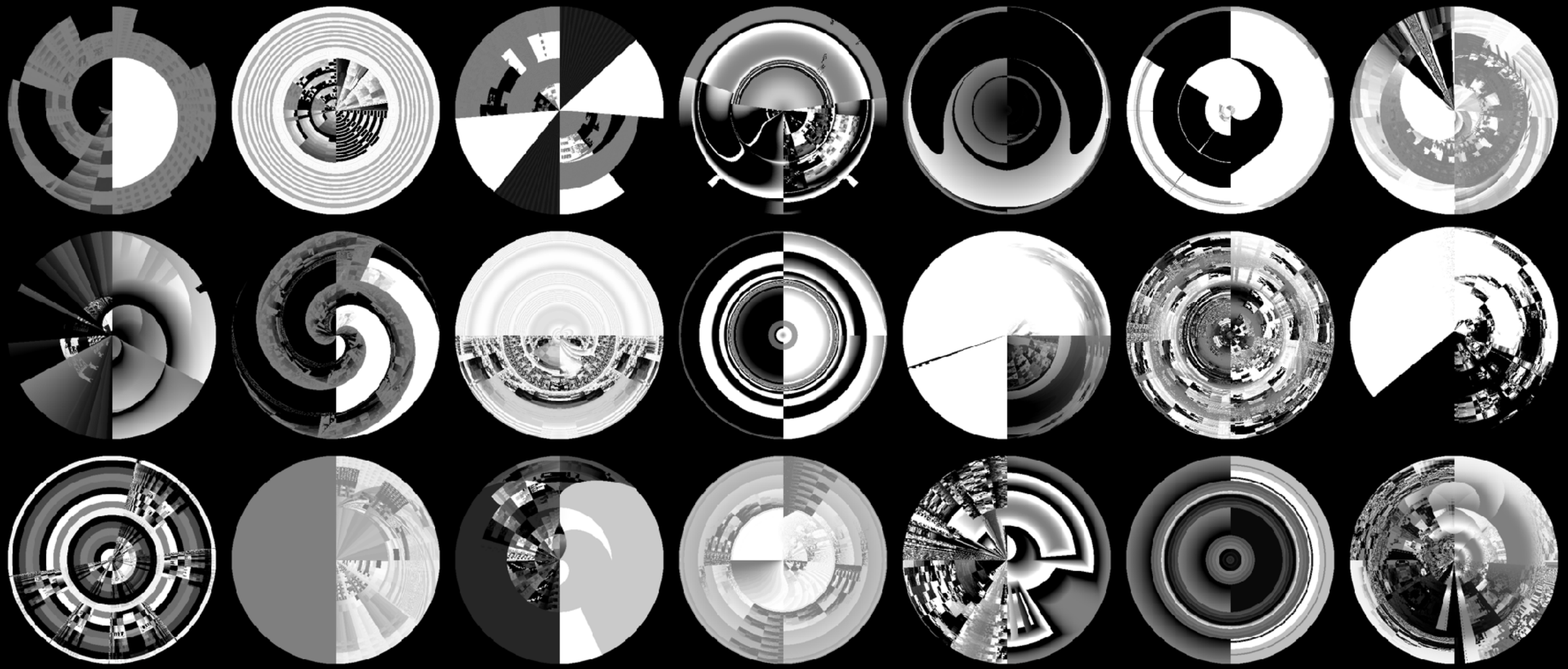
Images generated with NEvAr+TensorGP

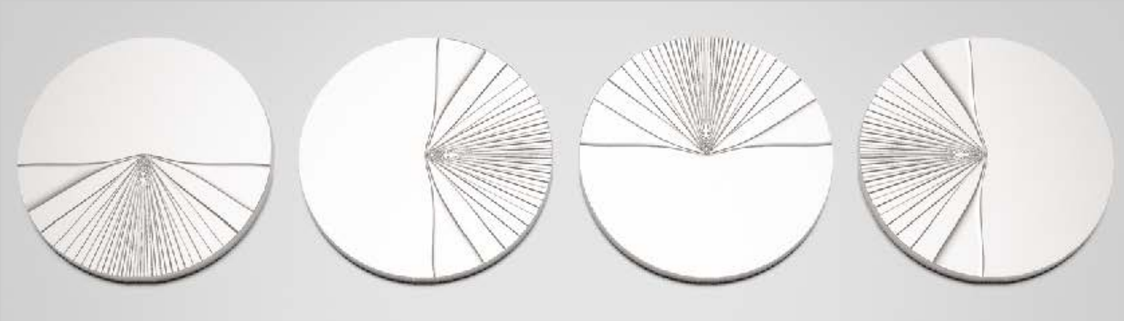


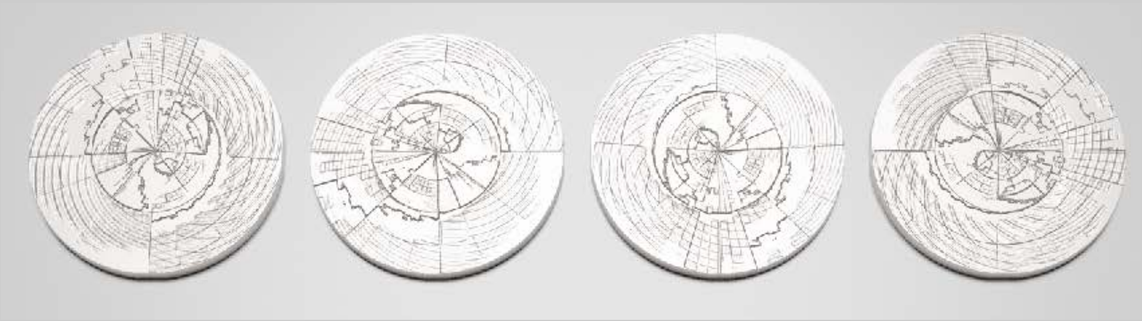
Population of prompts being evolved in MetaPrompter


/generation_00001 (2/323)







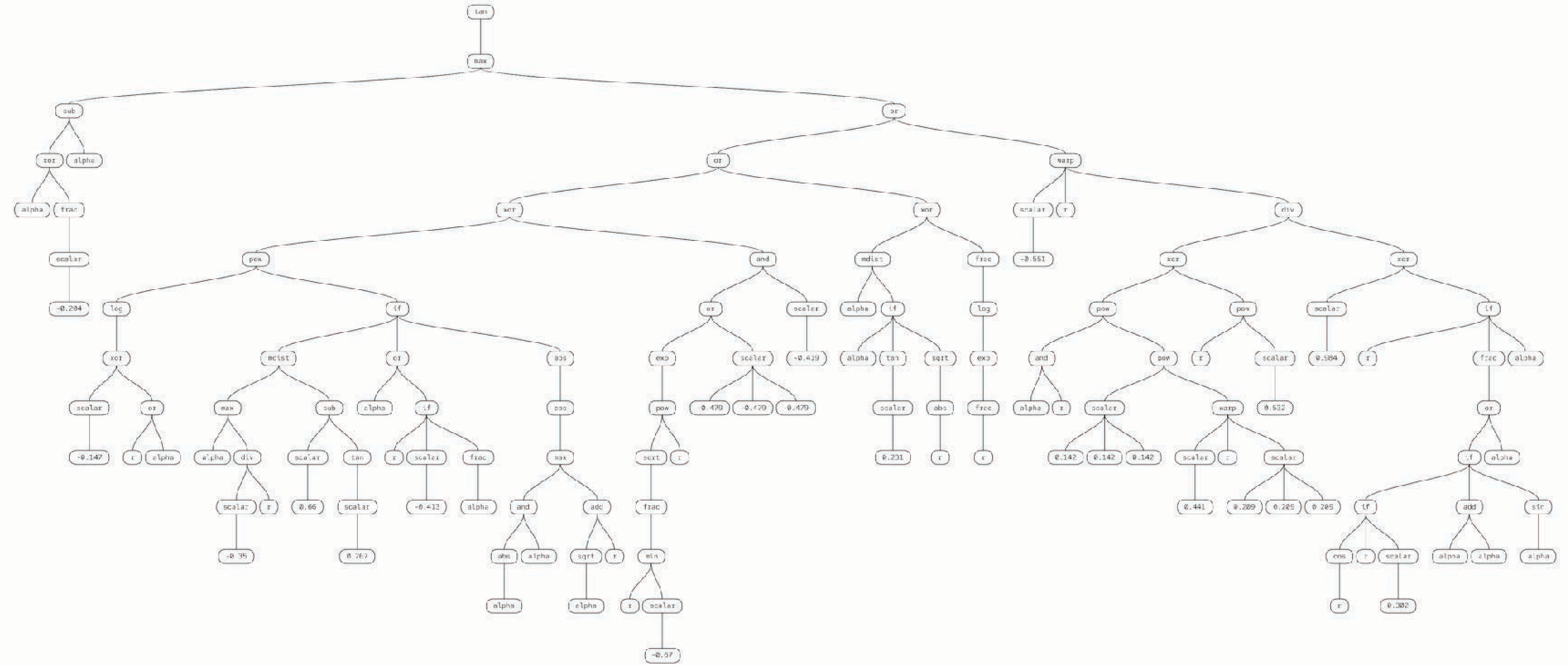


By Humans for AI

By Humans for AI

- Graphical representation of mathematical expression that generates the image depicted in the other face.

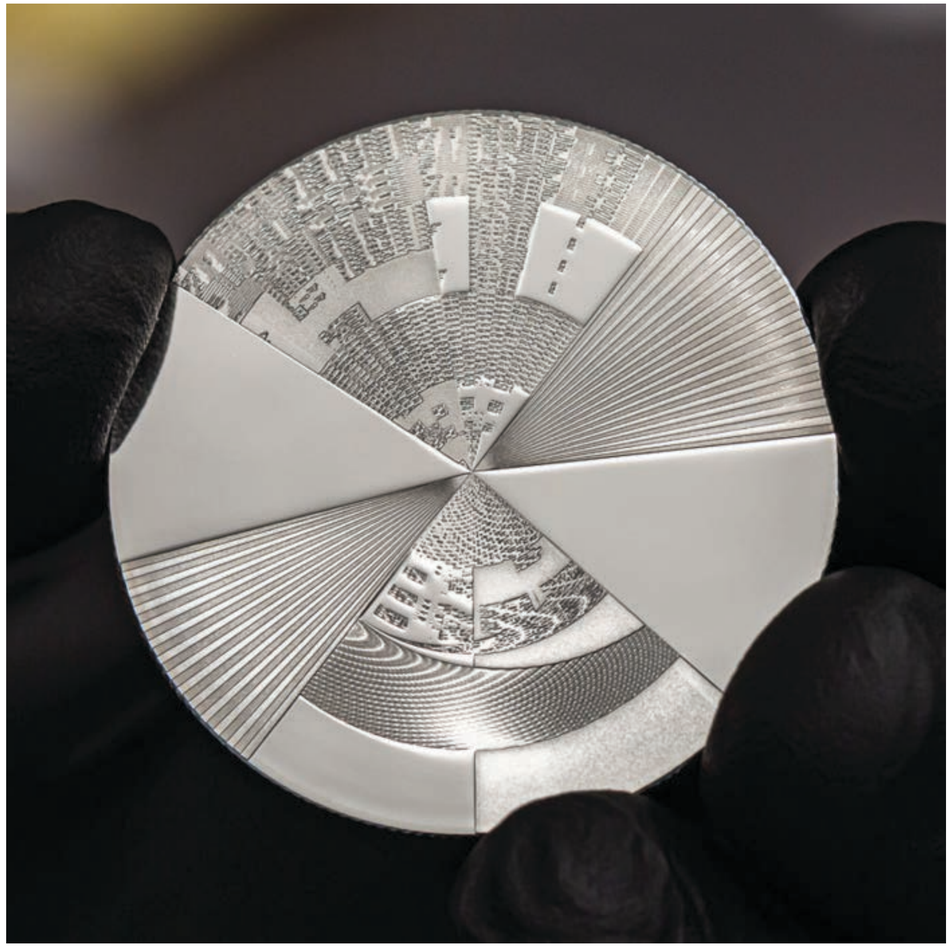
```
tan(max(sub(xor(alpha,frac(scalar(-0.204))),alpha),or(or(xor(pow(log(xor(scalar(-0.147),or(r,alpha))),if(mdist(max(alpha,div(scalar(-0.35),r)),sub(scalar(0.66),tan(scalar(0.267)))),or(alpha,if(r,
scalar(-0.413),frac(alpha))),abs(cos(max(and(abs(alpha),alpha),add(sqrt(alpha),r))))),and(or(exp(pow(sqrt(frac(min(r,scalar(-0.67)))),r)),scalar(-0.479,-0.479,-0.479)),scalar(-0.419))),xor(mdist(
alpha,if(alpha,tan(scalar(0.231)),sqrt(abs(r)))),frac(log(exp(frac(r)))))),warp(scalar(-0.551),r,div(xor(pow(and(alpha,r),pow(scalar(0.142,0.142,0.142),warp(scalar(0.441),r,scalar(0.209,0.209,0.209)))),
pow(r,scalar(0.532))),xor(scalar(0.984),if(r,frac(or(if(if(cos(r),r,scalar(0.302)),add(alpha,alpha),sin(alpha)),alpha)),alpha)))))))
```



Visualisation of the genetic code
of the evolved image selected for the coin

Side by Humans for AI


MUNDO DIGITAL
CISUC
10 EURO
2023
PORTUGAL
CASA DA MOEDA



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```


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2023
CASA DA MOEDA
CISUC

Generating
letters

Generating
faces

Generating
coins

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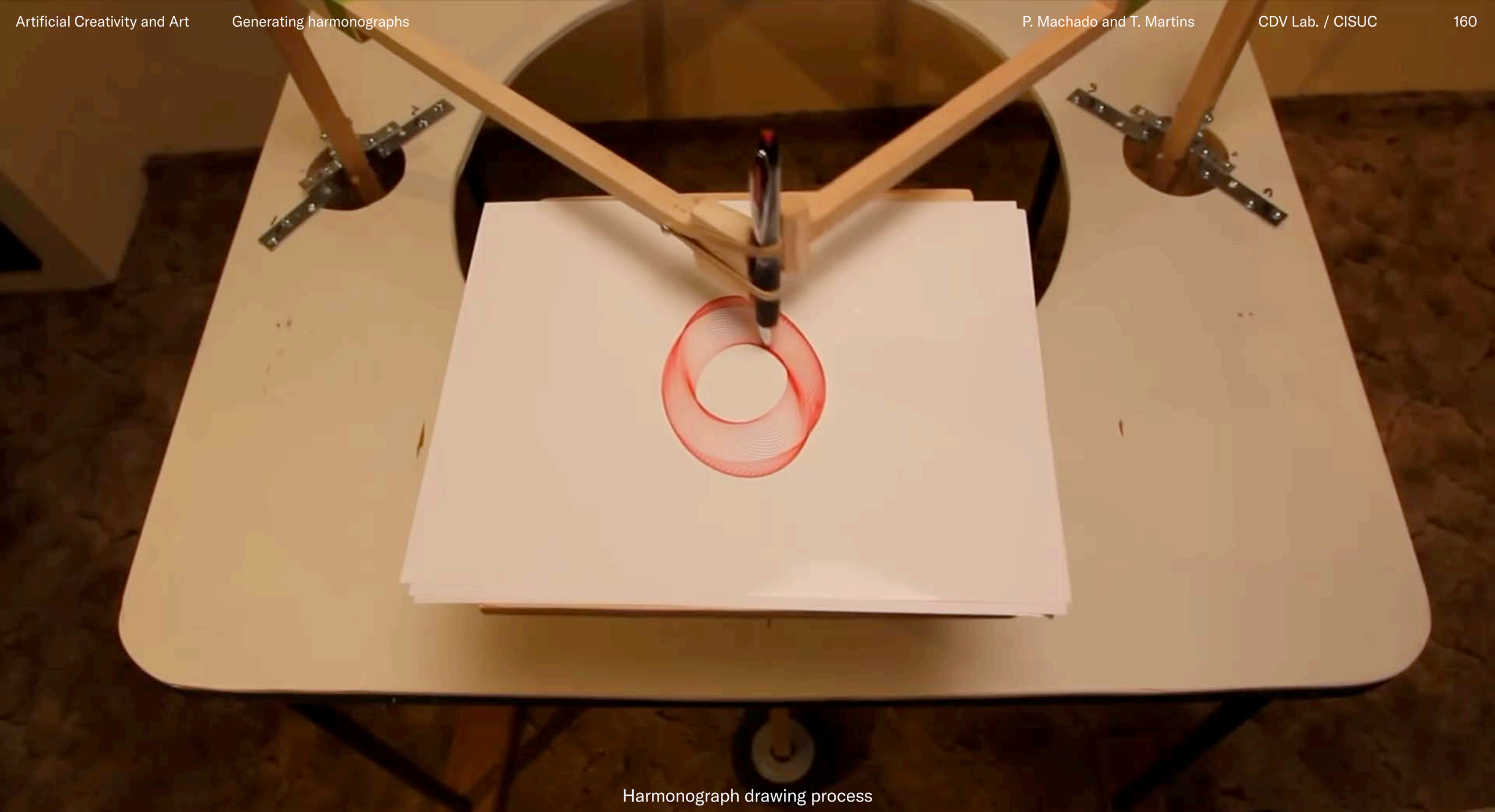
- Computational Design and Visualization Lab. website: http://cdv.dei.uc.pt

Generating
letters

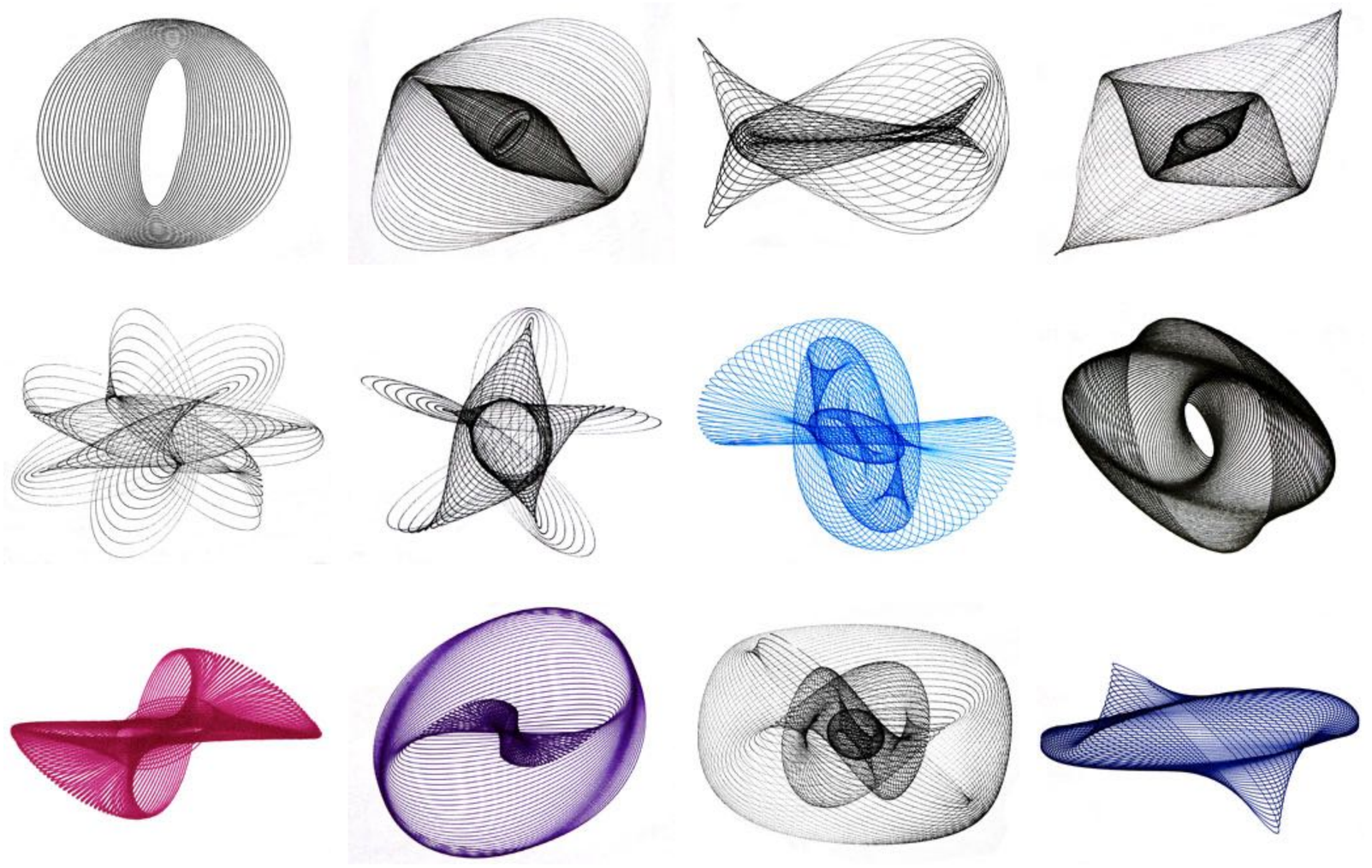
Generating
faces

Generating
coins

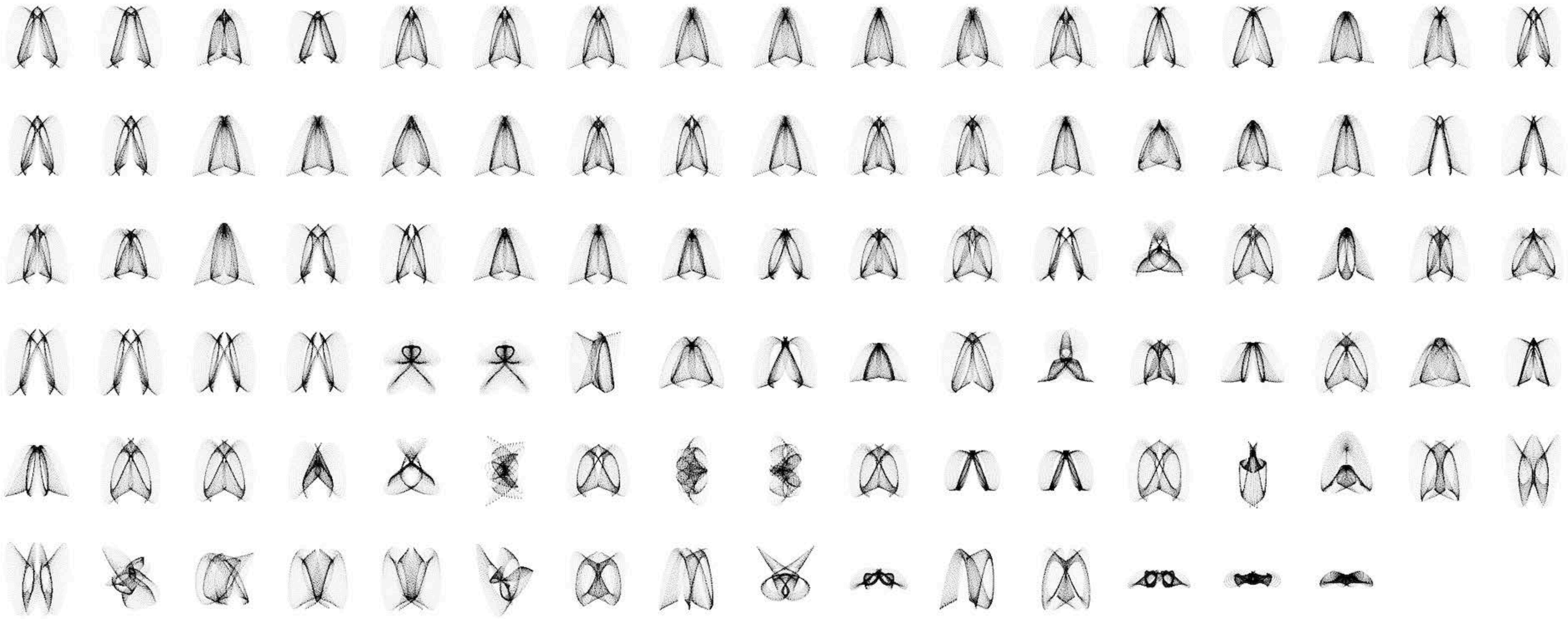
Generating
harmonographs



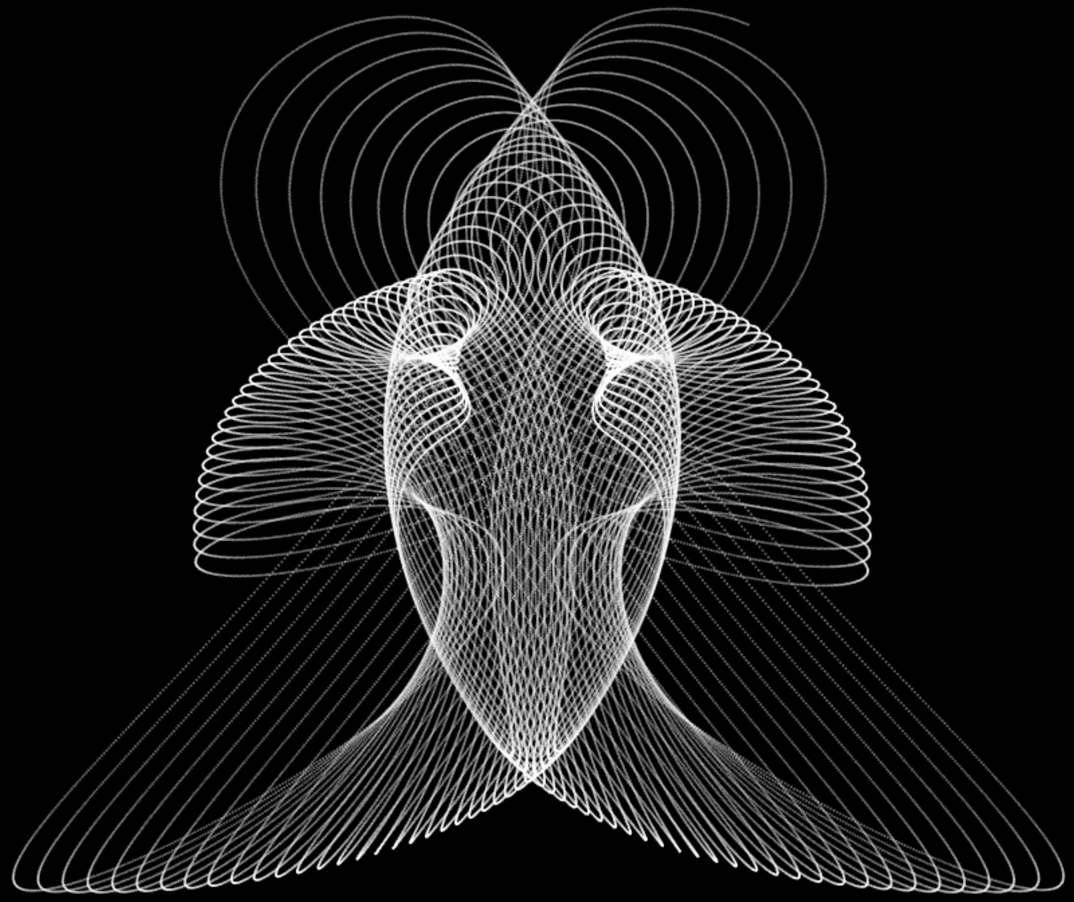
Harmonograph drawing process

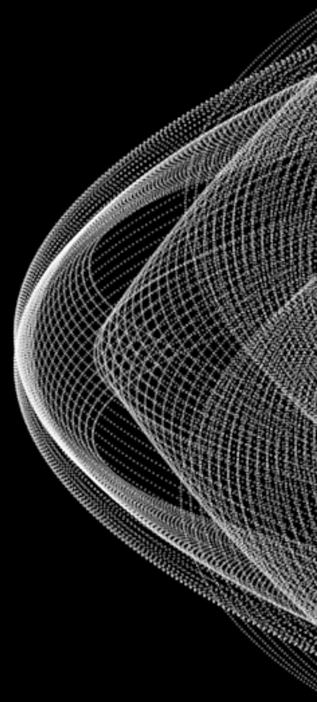


Pendulum Rotary Harmonograph Results,
Karl Sims (2009)

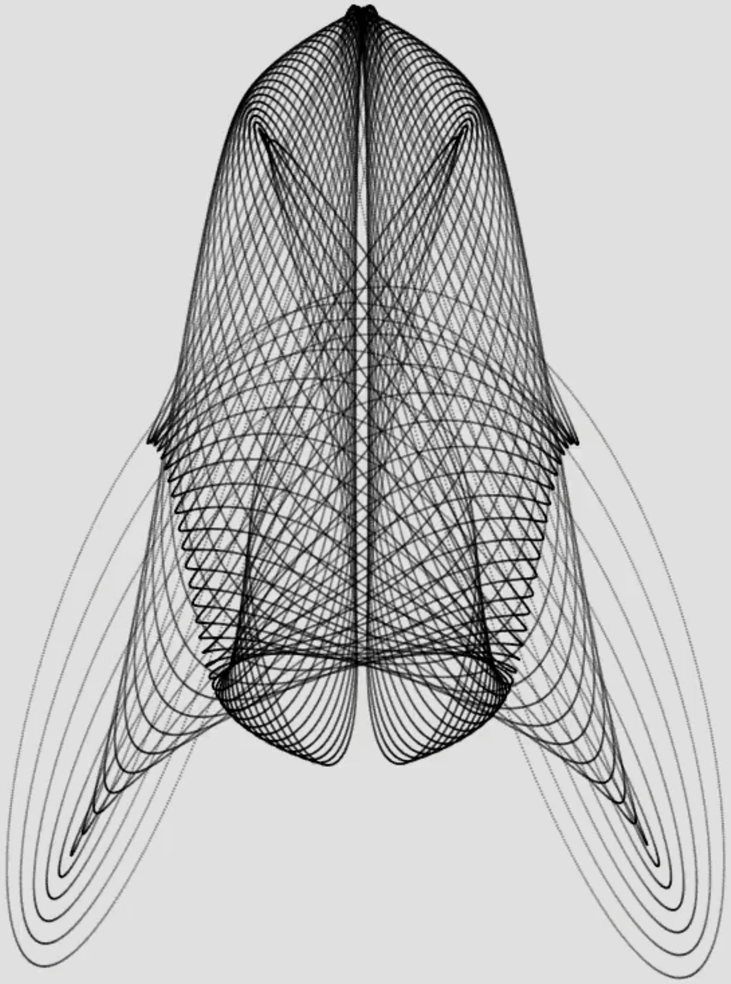


Generated harmonographs





Harmonographs evolved to resemble letters



Morph animation between different harmonographs

Drawing generated harmonograph using a pen plotter

What you will need

- Computer
- Install Processing: processing.org
- Download these files: github.com/tiagofmartins/evolving-harmonographs

14th SYMPOSIUM OF BIAL FOUNDATION
BEHIND AND BEYOND THE BRAIN

Thank you.

Penousal Machado
University of Coimbra
machado@dei.uc.pt

Tiago Martins
University of Coimbra
tiagofm@dei.uc.pt

1 2 90 UNIVERSIDADE D COIMBRA

dei departamento de engenharia informática

LASI Intelligent Systems Associate Laboratory

CISUC COGNITIVE AND MEDIA SYSTEMS

COMPUTATIONAL DESIGN & VISUALIZATION LAB.