EVOLUTIONARY ART AND DESIGN: REPRESENTATION, FITNESS AND INTERACTION

PENOUSAL MACHADO
UNIVERSITY OF COIMBRA, CISUC
COIMBRA, PORTUGAL
MACHADO@DEI.UC.PT

This work is licensed under a Creative Commons Attribution International 4.0 License.

GECCO '21 COMPANION, JULY 10–14, 2021, LILLE, FRANCE
© 2021 COPYRIGHT IS HELD BY THE OWNER/AUTHOR(S).
ACM ISBN 978-1-4503-8391-6/21/07
[HTTPS://DOI.ORG/10.1145/3448726.3461398](https://doi.org/10.1145/3448726.3461398)

PENOUSAL MACHADO

PENOUSAL MACHADO IS ASSOCIATE
PROFESSOR AT THE DEPARTMENT OF
INFORMATICS OF THE UNIVERSITY OF
COIMBRA IN PORTUGAL.

HE IS A DEPUTY DIRECTOR OF THE CENTRE
FOR INFORMATICS AND SYSTEMS OF THE
UNIVERSITY OF COIMBRA (CISUC), THE
COORDINATOR OF THE COGNITIVE AND MEDIA
SYSTEMS GROUP AND THE SCIENTIFIC
DIRECTOR OF THE COMPUTATIONAL DESIGN
AND VISUALIZATION LAB. OF CISUC.

HIS RESEARCH INTERESTS INCLUDE
EVOLUTIONARY COMPUTATION,
COMPUTATIONAL CREATIVITY, ARTIFICIAL
INTELLIGENCE AND INFORMATION
VISUALIZATION.

PRESENTATION OUTLINE

- INTRODUCTION
- REPRESENTATION
- EVALUATION
- INTERACTION

"UNTITLED"
© TIAGO MARTINS AND PENOUSAL MACHADO, 2014
CDV.DEI.UC.PT/PHOTOGROWTH-ANT-PAINTING/

INTRODUCTION

"IN THE BEGINNING"
IRIS SOMERSET-PRINT, 34" X 46"
© STEVEN ROOKE, 1997
[HTTP://SROOKE.COM/](http://srooke.com/)

RICHARD DAWKINS

DAWKINS, R.: THE BLIND WATCHMAKER, 1986

WILLIAM LATHAM

"BLACK FORM SYNTH"
WILLIAM LATHAM, 1985
V&A COLLECTION
[HTTPS://COLLECTIONS.VAM.AC.UK/ITEM/01276894/BLACK-FORM-SYNTH-OFFSET-LITHOGRAPH-WILLIAM-LATHAM/](https://collections.vam.ac.uk/item/01276894/black-form-synth-offset-lithograph-william-latham/)

TODD + LATHAM

"ARTIST AS GARDENER"
© WILLIAM LATHAM, 1987
[HTTP://LATHAM-MUTATOR.COM](http://latham-mutator.com)

TODD, S. AND LATHAM, W.: EVOLUTIONARY ART AND COMPUTER

KARL SIMS

PLANT LIKE SHAPES
SIMS, K.: ARTIFICIAL EVOLUTION FOR COMPUTER GRAPHICS. SIGGRAPH '91 PROCEEDINGS: 319-328. 1991

KARL SIMS

EXPRESSION BASED IMAGES

SIMS, K.: ARTIFICIAL EVOLUTION FOR COMPUTER GRAPHICS. SIGGRAPH '91 PROCEEDINGS: 319-328. 1991

KARL SIMS

GENETIC CROSS DISSOLVES

PRIMORDIAL DANCE

©KARL SIMS, 1991

SIMS, K.: ARTIFICIAL EVOLUTION FOR COMPUTER GRAPHICS. SIGGRAPH '91 PROCEEDINGS: 319-328. 1991

REPRESENTATION

PROCEDURAL

- EXPRESSION-BASED
- NEAT
- CFDGS

DECLARATIVE

- PARAMETRIC
- DESCRIPTIVE

"UNTITLED"
©PENOUSAL MACHADO, 1998

PROCEDURAL REPRESENTATIONS

"UNTITLED"
©PENOUSAL MACHADO, 1999

EXPRESSION BASED EVOLUTION

REPRESENTATION

THE INDIVIDUALS ARE TREES

FUNCTION SET

+, -, *, %, SIN, IF, XOR, ...

TERMINAL SET

X, Y, CONSTANTS

3D-VECTORS (FOR COLOR)

X

COS(X+Y)

COS(4*X)

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

EXPRESSION BASED EVOLUTION

3RD GENERATION

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

EXPRESSION BASED EVOLUTION

1ST GENERATION

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

"UNTITLED"
©PENOUSAL MACHADO, 1999

EVOLVING ASSEMBLAGES

EVOLVING IMAGE FILTERS

REPRESENTATION

EACH GENOTYPE HAS FIVE CHROMOSOMES

< TYPE, ROTATION, SIZE, X-POSITION, Y-POSITION >

FUNCTION SET

SIN, COS, MAX, MIN, ABS, +, -, X, %, DIFF

TERMINAL SET

X, Y, IMAGE, RANDOMCONSTANTS

F. GRAÇA AND P. MACHADO, "EVOLVING ASSEMBLAGES," IJART, VOL. 8, ISS. 2, PP. 167-184, 2015

WHAT CAN YOU EVOLVE?

IN PRACTICE...

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

NEAT

NEUROEVOLUTION OF AUGMENTING TOPOLOGIES

INTRODUCED BY KENNETH STANLEY TO EVOLVE NEURAL NETWORKS

SHARES SIMILARITIES WITH EXPRESSION BASED APPROACHES

- THE GENOTYPE IS A CPPN
- THE PHENOTYPE IS AN IMAGE

APPEARS TO HAVE BETTER EVOLVABILITY

HELMES L, CLUNE J (2017) IMPROVING HYBRID: HOW TO BEST COMBINE INDIRECT AND DIRECT ENCODING IN EVOLUTIONARY ALGORITHMS. PLOS ONE 12(3): E0174635. [HTTPS://DOI.ORG/10.1371/JOURNAL.PONE.0174635](https://doi.org/10.1371/journal.pone.0174635)

PICBREEDER

J. SECRETAN, N. BEATO, D. B. D. AMBROSIO, A. RODRIGUEZ, A. CAMPBELL, AND K. O. STANLEY. 2008. PICBREEDER: EVOLVING PICTURES COLLABORATIVELY ONLINE. IN PROCEEDINGS OF THE SIGCHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS (CHI '08). ACM, NEW YORK, NY, USA, 1759-1768.

CFDG

CONTEXT FREE ART

POPULAR OPEN-SOURCE APPLICATION
ALLOWS THE SPECIFICATION OF FAMILIES OF SHAPES

USES A SIMPLE AND COMPACT LANGUAGE

[HTTPS://WWW.CONTEXTFREEART.ORG/](https://www.contextfreeart.org/)

CFDG

NON DETERMINISTIC GRAMMARS

EACH GENOTYPE IS A WELL-CONSTRUCTED
CFDG GRAMMAR.

THE GENOTYPES ARE REPRESENTED BY
DIRECTED GRAPHS

SUBGRAPH CROSSOVER

TEN MUTATION OPERATORS

P. MACHADO, H. NUNES, AND J. ROMERO, "GRAPH-BASED
EVOLUTION OF VISUAL LANGUAGES," IN APPLICATIONS OF
EVOLUTIONARY COMPUTATION, EVOAPPLICATIONS 2010,
ISTANBUL, TURKEY, APRIL 7-9, 2010, PROCEEDINGS, PART II,
2010, PP. 271-280.

CFDG

P. MACHADO, H. NUNES, AND J. ROMERO, "GRAPH-BASED EVOLUTION OF VISUAL LANGUAGES," IN APPLICATIONS OF EVOLUTIONARY COMPUTATION,
EVOAPPLICATIONS 2010, ISTANBUL, TURKEY, APRIL 7-9, 2010, PROCEEDINGS, PART II, 2010, PP. 271-280.

DECLARATIVE REPRESENTATIONS

SAMPLE FRACTAL IMAGE GENERATED BY THE ELECTRIC SHEEP
©SCOT DRAVES, 2006
[HTTPS://ELECTRICSHEEP.ORG](https://ELECTRICSHEEP.ORG)

PARAMETRIC

ELECTRIC SHEEP

THE GENOTYPE IS A SET OF PARAMETERS FOR
A GENERATIVE SYSTEM

IN THIS CASE, A SET OF PARAMETERS FOR
THE FRACTAL FLAME ALGORITHM

DRAVES, S.: "EVOLUTION AND COLLECTIVE INTELLIGENCE OF THE ELECTRIC SHEEP,"
THE ART OF ARTIFICIAL EVOLUTION, 2008.

©SCOT DRAVES, 2006
[HTTPS://ELECTRICSHEEP.ORG](https://ELECTRICSHEEP.ORG)

PARAMETRIC

EVOLVING CARTOON FACES
MATHEW LEWIS

[HTTPS://WWW.ASC.OHIO-STATE.EDU/LEWIS.239/AED/FACES/](https://www.asc.ohio-state.edu/lewis.239/aed/faces/)

PARAMETRIC

EVOLVING HUMAN FIGURE GEOMETRY
MATHEW LEWIS

[HTTPS://WWW.ASC.OHIO-STATE.EDU/LEWIS.239/AED/FIGURES/](https://www.asc.ohio-state.edu/lewis.239/aed/figures/)

PARAMETRIC

SWARM VISUALIZATION

THE GENOTYPE IS A SET OF PARAMETERS FOR
SWARM SYSTEMS THAT RESPOND TO
CONSUMER PATTERNS

[CDV.DEI.UC.PT/SWARMING/](http://cdv.dei.uc.pt/swarming/)

C. MAÇAS, N. LOURENÇO, AND P. MACHADO, "EVOLVING VISUAL
ARTEFACTS BASED ON CONSUMPTION PATTERNS," INTERNATIONAL
JOURNAL OF ARTS AND TECHNOLOGY, VOL. 12, ISS. 1, P. 60, 2020.

[CDV.DEI.UC.PT/SWARMING/](http://cdv.dei.uc.pt/swarming/)

C. MAÇAS, N. LOURENÇO, AND P. MACHADO, "EVOLVING VISUAL ARTEFACTS BASED ON CONSUMPTION
PATTERNS," INTERNATIONAL JOURNAL OF ARTS AND TECHNOLOGY, VOL. 12, ISS. 1, P. 60, 2020.

PARAMETRIC

SHOE DESIGN

THE GENOTYPE IS A SET OF PARAMETERS THAT SPECIFIES THE PROPERTIES OF EACH SHOE PART

[HTTPS://CDV.DEI.UC.PT/EVOFASHION-CUSTOMISING-FASHION-THROUGH-EVOLUTION/](https://cdv.dei.uc.pt/evofashion-customising-fashion-through-evolution/)

N. LOURENÇO, F. ASSUNÇÃO, C. MACÃS, AND P. MACHADO, "EVOFASHION: CUSTOMISING FASHION THROUGH EVOLUTION," IN INTERNATIONAL CONFERENCE ON EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC AND ART, 2017.

DESCRIPTIVE

EVOLVING LINE DRAWINGS

FOR EACH LINE THE GENOTYPE ENCODES:

- STROKE TYPE
- SYMMETRY TYPE
- SPLINE/STRAIGHT
- COORDINATES
- PERTURBATION FACTOR
- MUTATION RATE

BAKER, ELLIE AND MARGO SELTZER. 1993. EVOLVING LINE DRAWINGS. HARVARD COMPUTER SCIENCE GROUP TECHNICAL REPORT TR-21-93.

DESCRIPTIVE

PERCEPTION ENGINES

FOR EACH LINE THE GENOTYPE ENCODES:

- START AND END COORDINATES
- START AND END SIZE
- COLOR

©TOM WHITE, 2018

[HTTPS://AIARTISTS.ORG/TOM-WHITE](https://aiartists.org/tom-white)
[HTTPS://MEDIUM.COM/ARTISTS-AND-MACHINE-INTELLIGENCE/PERCEPTION-ENGINES-8A46BC598D57](https://medium.com/artists-and-machine-intelligence/perception-engines-8a46bc598d57)

DESCRIPTIVE

SCALABLE VECTOR GRAPHICS

THE GENOTYPE IS A SVG FILE

SPECIALISED CROSSOVER AND MUTATION OPERATORS

INITIALIZED WITH HUMAN-CREATED SVG FILES

E. DEN HEIJER AND A. E. EIBEN. 2012. EVOLVING POP ART USING SCALABLE VECTOR GRAPHICS. IN PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN. SPRINGER-VERLAG, BERLIN, HEIDELBERG, 48-59.

EVALUATION

USER-GUIDED
HARDWIRED
FUNCTIONAL
ML BASED
ADVERSARIAL

"LESSER PANDA"
©PENOUSAL MACHADO, 2021

USER GUIDED EVOLUTION

KEY PROBLEMS

TIME CONSUMING

USER FATIGUE

NOVELTY VS QUALITY

LIMITED POPULATION SIZE

LIMITED NUMBER OF GENERATIONS

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

USER GUIDED EVOLUTION

ADVANTAGES

PHENOTYPE DATABASE

GOING BACK IN TIME

OPPORTUNISTIC Crossover AND MUTATION

COMBINING THE RESULTS OF MULTIPLE RUNS

CURATORSHIP

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101-119, 2002.

TARGET DRIVEN FITNESS

TRY TO MATCH A TARGET IMAGE

THE SUCCESS DEPENDS ON THE REPRESENTATION

DESCRIPTIVE REPRESENTATIONS TEND TO WORK BETTER

FOR PROCEDURAL REPRESENTATIONS IT CAN BE SEEN AS PROGRAMMATIC COMPRESSION

IT CAN BE A USELESS PURSUIT !

[HTTPS://ROGERJOHANSSON.BLOG/2008/12/07/GENETIC-PROGRAMMING-EVOLUTION-OF-MONA-LISA/](https://rogerjohansson.blog/2008/12/07/genetic-programming-evolution-of-mona-lisa/)

TARGET DRIVEN

TRY TO MATCH A TARGET IMAGE

THE SUCCESS DEPENDS ON THE
REPRESENTATION

DESCRIPTIVE REPRESENTATIONS TEND TO
WORK BETTER

FOR PROCEDURAL REPRESENTATIONS IT CAN
BE SEEN AS PROGRAMMATIC COMPRESSION

IT CAN BE A USELESS PURSUIT !

[HTTPS://DIPAOLA.ORG/EVOLVE/](https://dipaola.org/evolve/)

AESTHETIC HARDWIRED FITNESS

SOME IDEAS

GOLDEN RATIO

FRACTAL DIMENSION

LACUNARITY

ZIPF'S LAW

...

SHORTCOMINGS

NEITHER NECESSARY

NOR SUFFICIENT

SOME ARE "FAKE NEWS"

AESTHETIC HARDWIRED FITNESS

THE IDEA

COMPLEXITY IS AN
AESTHETICALLY RELEVANT
CHARACTERISTIC.

IMAGES THAT ARE VISUALLY
COMPLEX YET SIMPLE TO
PROCESS TEND TO BE
AESTHETICALLY INTERESTING

AESTHETIC HARDWIRED FITNESS

THE IMPLEMENTATION

ESTIMATE IMAGE COMPLEXITY USING
FRACTAL AND JPEG COMPRESSION.

USE THESE ESTIMATES TO COMPARE
AND EVALUATE IMAGES.

LIMITATIONS:

ONLY FOR BLACK AND WHITE IMAGES.

P. MACHADO AND A. CARDOSO, "ALL THE TRUTH
ABOUT NEVAR," APPLIED INTELLIGENCE,
SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL.
16, ISS. 2, PP. 101-119, 2002.

AESTHETIC HARDWIRED FITNESS

SAME FITNESS DIFFERENT
REPRESENTATIONS

P. MACHADO, J. CORREIA, AND F.
ASSUNÇÃO, "GRAPH-BASED
EVOLUTIONARY ART," IN HANDBOOK OF
GENETIC PROGRAMMING APPLICATIONS,
A. H. GANDOMI, A. H. ALAVI, AND C. RYAN,
EDS., 2015, PP. 3-36.

AESTHETIC HARDWIRED FITNESS

MAXIMIZING THE NUMBER OF
CONTRASTING COLORS

P. MACHADO, J. CORREIA, AND F.
ASSUNÇÃO, "GRAPH-BASED
EVOLUTIONARY ART," IN HANDBOOK OF
GENETIC PROGRAMMING APPLICATIONS,
A. H. GANDOMI, A. H. ALAVI, AND C. RYAN,
EDS., 2015, PP. 3-36.

AESTHETIC HARDWIRED FITNESS

PROMOTING A "NATURAL"
DISTRIBUTION OF COLOR
GRADIENTS

P. MACHADO, J. CORREIA, AND F.
ASSUNÇÃO, "GRAPH-BASED
EVOLUTIONARY ART," IN HANDBOOK OF
GENETIC PROGRAMMING APPLICATIONS,
A. H. GANDOMI, A. H. ALAVI, AND C. RYAN,
EDS., 2015, PP. 3-36.

AESTHETIC HARDWIRED FITNESS

COMBINING SEVERAL HARDWIRED
FITNESS FUNCTIONS

COMPLEXITY, CONTRASTING
COLORS AND COLOR GRADIENTS

P. MACHADO, J. CORREIA, AND F.
ASSUNÇÃO, "GRAPH-BASED
EVOLUTIONARY ART," IN HANDBOOK OF
GENETIC PROGRAMMING APPLICATIONS,
A. H. GANDOMI, A. H. ALAVI, AND C. RYAN,
EDS., 2015, PP. 3-36.

AESTHETIC HARDWIRED FITNESS

YET ANOTHER REPRESENTATION
COMPLEXITY

C. MAÇAS, N. LOURENÇO, P. MACHADO,
"INTERACTIVE EVOLUTION OF SWARMS
FOR THE VISUALIZATION OF
CONSUMPTIONS", (TO APPEAR).

FUNCTIONAL HARDWIRED FITNESS

TYPOGRAPHIC POSTERS

FITNESS DEPENDS ON THE
ORGANIZATION OF THE TEXT
BOXES.

PREVENT OVERLAPS

MAXIMIZE USED SPACE.

S. REBELO, J. BICKER, AND P. MACHADO,
"EVOLUTIONARY EXPERIMENTS IN TYPESETTING OF
LETTERPRESS-INSPIRED POSTERS," IN PROCEEDINGS
OF THE ELEVENTH INTERNATIONAL CONFERENCE ON
COMPUTATIONAL CREATIVITY, SEPTEMBER 7-11,
2020, 2020.

HARDWIRED FITNESS FUNCTIONS

JOÃO MIGUEL CUNHA ET AL.

EMOJINATING
PRODUCING VISUAL
REPRESENTATIONS OF CONCEPTS

[HTTP://EMOJINATING.DEI.UC.PT/](http://emojinating.dei.uc.pt/)

J. M. CUNHA, P. MARTINS, N. LOURENÇO, AND P. MACHADO, "EMOJINATING CO-CREATIVITY: INTEGRATING SELF-EVALUATION AND CONTEXT-ADAPTATION," IN PROCEEDINGS OF THE ELEVENTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY, ICC3 2020, COIMBRA, PORTUGAL, SEPTEMBER 7-11, 2020, 2020, PP. 85-88.

HARDWIRED FITNESS FUNCTIONS

JOÃO MIGUEL CUNHA ET AL.
EVER CHANGING FLAGS

J. M. CUNHA, P. MARTINS, AND P. MACHADO, "EVER-CHANGING FLAGS: IMPACT AND ETHICS OF MODIFYING NATIONAL SYMBOLS," IN PROCEEDINGS OF THE ELEVENTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY, ICC3 2020, COIMBRA, PORTUGAL, SEPTEMBER 7-11, 2020, 2020, PP. 410-413.

FUNCTIONAL AND AESTHETIC

DISNEY MEETS DARWIN
JEFFERY VENTRELLA

VENTRELLA, J.: "DISNEY MEETS DARWIN : AN EVOLUTION-BASED INTERFACE FOR EXPLORATION AND DESIGN OF EXPRESSIVE ANIMATED BEHAVIOR", THESIS (M.S.), MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1994.

[HTTP://WWW.DISNEYMEETSDARWIN.COM/](http://www.disneymeetsdarwin.com/)

MACHINE LEARNING

MACHINE LEARNING

LEARNING USER PREFERENCES

Figure 7. Only a small portion of the input layer is shown. There are a total of 9×9 (81) 6×6 input groups and a total of 4×4 (16) 12×12 input groups. Each 6×6 group is connected to three units in hidden layer 1. Each 12×12 group is also connected to three units in hidden layer 1. Only the 12×12 feature detectors are shown. The bias unit (not shown) is connected to each of the hidden units (in hidden layer 1 and in hidden layer 2) and the output layer. The total number of connections is $(81 \times (36 + 1) \times 3) + (16 \times (144 + 1) \times 3) + ((291 + 1) \times 10) + (10 + 1) = 18\,822$.

BALUJA S, POMERLAU D, TODD J. TOWARDS AUTOMATED ARTIFICIAL EVOLUTION FOR COMPUTER-GENERATED IMAGES. CONNECTION SCIENCE 1994; 6(2):325-54

MACHINE LEARNING

RESULTS

RANDOM VS. GUIDED BY THE ANN.

WHY?

GP IS FINDING SHORTCUTS.

SPECTOR, L., ALPERN, A.:
INDUCTION AND RECAPITULATION
OF DEEP MUSICAL STRUCTURE.
IJCAI-95 WORKSHOP ON
ARTIFICIAL INTELLIGENCE AND
MUSIC (1995) 41-48

BALUJA S, POMERLAU D, TODD J. TOWARDS AUTOMATED ARTIFICIAL EVOLUTION FOR COMPUTER-GENERATED IMAGES. CONNECTION SCIENCE 1994; 6(2):325-54

MACHINE LEARNING

THE IDEA

COMBINE A GENERAL PURPOSE
EVOLUTIONARY ART SYSTEM WITH AN
IMAGE CLASSIFIER TRAINED TO
RECOGNIZE FACES, OR OTHER TYPES
OF OBJECTS, TO EVOLVE IMAGES OF
HUMAN FACES.

J. ROMERO, P. MACHADO, A. SANTOS, AND A.
CARDOSO, "ON THE DEVELOPMENT OF CRITICS
IN EVOLUTIONARY COMPUTATION ARTISTS,"
EVOWORKSHOP 2003, ESSEX, UK, APRIL
14-16, 2003, PROCEEDINGS, 2003, PP.
559-569.

MACHINE LEARNING

EVOLVING FACES

THE EC SYSTEM ALWAYS FINDS IMAGES THAT ARE RECOGNIZED AS FACES.

OFTEN THESE IMAGES HAVE NO RESEMBLANCE WITH A FACE.

P. MACHADO, J. CORREIA, AND J. ROMERO,
"EXPRESSION-BASED EVOLUTION OF FACES,"
EVOMUSART 2012, MÁLAGA, SPAIN, APRIL
11-13, 2012. PROCEEDINGS, 2012, PP.
187-198.

MACHINE LEARNING

EVOLVING FACES

THE EC SYSTEM ALWAYS FINDS IMAGES THAT ARE RECOGNIZED AS FACES.

OFTEN THESE IMAGES HAVE NO RESEMBLANCE WITH A FACE.

P. MACHADO, J. CORREIA, AND J. ROMERO,
"EXPRESSION-BASED EVOLUTION OF FACES,"
EVOMUSART 2012, MÁLAGA, SPAIN, APRIL
11-13, 2012. PROCEEDINGS, 2012, PP.
187-198.

MACHINE LEARNING

DEEP NEURAL NETWORKS ARE ALSO EASILY FOOLED

NGUYEN A, YOSINSKI J, CLUNE J. DEEP NEURAL NETWORKS ARE EASILY FOOLED: HIGH CONFIDENCE PREDICTIONS FOR UNRECOGNIZABLE IMAGES. IN COMPUTER VISION AND PATTERN RECOGNITION (CVPR '15), IEEE, 2015.

MACHINE LEARNING

EVOLVING FACES

SOME SUCCESS STORIES.

P. MACHADO, J. CORREIA, AND J. ROMERO,
"EXPRESSION-BASED EVOLUTION OF FACES,"
EVOMUSART 2012, MÁLAGA, SPAIN, APRIL
11-13, 2012. PROCEEDINGS, 2012, PP.
187-198.

MACHINE LEARNING

EVOLVING LEAFS

J. CORREIA, P. MACHADO, J. ROMERO, AND A. CARBALLAL, "EVOLVING FIGURATIVE IMAGES USING EXPRESSION-BASED EVOLUTIONARY ART," ICCV 2013, PP. 24-31.

MACHINE LEARNING

EVOLVING LIPS

J. CORREIA, P. MACHADO, J. ROMERO, AND A. CARBALLAL, "EVOLVING FIGURATIVE IMAGES USING EXPRESSION-BASED EVOLUTIONARY ART," ICCV 2013, PP. 24-31.

MACHINE LEARNING

PROCEDURAL VS DESCRIPTIVE REPRESENTATIONS

EXPRESSION-BASED

CFDGS

VECTORIAL REPRESENTATIONS (INSPIRED ON THE WORK OF TOM WHITE)

@PENOUSAL MACHADO, 2021

MACHINE LEARNING

PROCEDURAL VS DESCRIPTIVE REPRESENTATIONS

EXPRESSION-BASED

CFDGS

VECTORIAL REPRESENTATIONS (INSPIRED ON THE WORK OF TOM WHITE)

@PENOUSAL MACHADO, 2021

MACHINE LEARNING

PROCEDURAL VS DESCRIPTIVE
REPRESENTATIONS

EXPRESSION-BASED

CFDGS

VECTORIAL REPRESENTATIONS (INSPIRED ON
THE WORK OF TOM WHITE)

@PENOUSAL MACHADO, 2021

MACHINE LEARNING

PROCEDURAL VS DESCRIPTIVE
REPRESENTATIONS

EXPRESSION-BASED

CFDGS

VECTORIAL REPRESENTATIONS (INSPIRED ON
THE WORK OF TOM WHITE)

@PENOUSAL MACHADO, 2021

MACHINE LEARNING

PROCEDURAL VS DESCRIPTIVE
REPRESENTATIONS

EXPRESSION-BASED

CFDGS

VECTORIAL REPRESENTATIONS (INSPIRED ON
THE WORK OF TOM WHITE)

@PENOUSAL MACHADO, 2021

MACHINE LEARNING

EVOLVING AMBIGUOUS IMAGES

IMAGES THAT INDUCE MULTISTABLE
PERCEPTION, WHICH OCCURS WHEN
THE BRAIN (OR THE COMPUTER) IS
CONFRONTED WITH VISUAL STIMULUS
THAT CAN BE INTERPRETED IN
MULTIPLE WAYS.

P. MACHADO, A. VINHAS, J. CORREIA, AND A.
EKÁRT, "EVOLVING AMBIGUOUS IMAGES,"
IJCAI 2015, BUENOS AIRES, ARGENTINA, JULY
25-31, 2015, 2015, PP. 2473-2479.

MACHINE LEARNING

EVOLVING AMBIGUOUS IMAGES

MACHINE LEARNING

EVOLVING AMBIGUOUS IMAGES

MACHINE LEARNING

ELAINE:
EVOLVING IMAGE ENHANCEMENT PIPELINES

CONVENTIONAL GP APPROACH

FUNCTION SET

IMAGE ENHANCEMENT OPERATIONS AND
CONDITIONAL EXPRESSIONS

TERMINAL SET

IMAGE AND IMAGE FEATURES

FITNESS ASSIGNED USING NIMA AESTHETIC

J. CORREIA, L. VIEIRA, N. RODRIGUEZ-FERNANDEZ, J. ROMERO,
AND P. MACHADO, "EVOLVING IMAGE ENHANCEMENT
PIPELINES," IN ARTIFICIAL INTELLIGENCE IN MUSIC, SOUND, ART
AND DESIGN, CHAM, 2021, PP. 82-97.

MACHINE LEARNING

EVOLVING FACES

J. CORREIA, T. MARTINS, P. MARTINS, AND P.
MACHADO, "X-FACES: THE EXPLOIT IS OUT
THERE," ICCV 2016, PP. 164-182.

MACHINE LEARNING

EVOLVING FACES

J. CORREIA, T. MARTINS, P. MARTINS, AND P. MACHADO, "X-FACES: THE EXPLOIT IS OUT THERE," ICCV 2016, PP. 164-182.

MACHINE LEARNING

UNRECOGNIZED FACES

J. CORREIA, T. MARTINS, P. MARTINS, AND P. MACHADO, "X-FACES: THE EXPLOIT IS OUT THERE," ICCV 2016, PP. 164-182.

MACHINE LEARNING

EVOLVING GLYPHS

T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOTYPE: FROM SHAPES TO GLYPHS," GECCO 2016, NEW YORK, NY, USA, 2016, PP. 261-268.

MACHINE LEARNING

EVOLVING GLYPHS

T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOTYPE: FROM SHAPES TO GLYPHS," BECCO 2016, NEW YORK, NY, USA, 2016, PP. 261-268.

MACHINE LEARNING

ÁDEA - EVOLVING GLYPHS

DIRECT MANIPULATION OF SVG GLYPHS

D. LOPES, J. CORREIA, AND P. MACHADO, "ÁDEA - EVOLVING GLYPHS FOR AIDING CREATIVITY IN TYPEFACE DESIGN," IN PROCEEDINGS OF THE 2020 GENETIC AND EVOLUTIONARY COMPUTATION CONFERENCE COMPANION, NEW YORK, NY, USA, 2020, PP. 97-98.

ANCIENT ARCHITECTURE

History of world architecture

Seton Lloyd
Hans Wolfgang Müller

ADVERSARIAL SYSTEMS

THE IDEA

CREATE A SYSTEM THAT IS CONSTANTLY RE-INVENTING ITSELF, CHANGING ITS STYLE FROM ONE RUN TO THE OTHER.

P. MACHADO, J. ROMERO, AND B. MANARIS, "EXPERIMENTS IN COMPUTATIONAL AESTHETICS: AN ITERATIVE APPROACH TO STYLISTIC CHANGE IN EVOLUTIONARY ART," IN THE ART OF ARTIFICIAL EVOLUTION: A HANDBOOK ON EVOLUTIONARY ART AND MUSIC, SPRINGER BERLIN HEIDELBERG, 2007, PP. 381-415.

ADVERSARIAL SYSTEMS

ADVERSARIAL LEARNING

CREATE 2 SETS OF IMAGES:

- FAMOUS PAINTINGS
- RANDOMLY GENERATED NEVAR IMAGES.

ADVERSARIAL SYSTEMS

ADVERSARIAL LEARNING

CREATE 2 SETS OF IMAGES:

- FAMOUS PAINTINGS
- RANDOMLY GENERATED NEVAR IMAGES.

TRAIN AN ANN TO DISTINGUISH BETWEEN THE TWO SETS.

USE NEVAR TO EVOLVE IMAGES THAT THE ANN CLASSIFIES AS PAINTINGS.

ADD THE EVOLVED IMAGES TO THE TRAINING SET, REPEAT!

ITERATION 1

ITERATION 2

ITERATION 4

ITERATION 7

ITERATION 8

ITERATION 9

ITERATION 10

ADVERSARIAL SYSTEMS

IDENTIFYING ATYPICAL IMAGES

THROUGHOUT THE ITERATIVE PROCESS
THE ANN ATTAINS SUCCESS RATES
ABOVE 99.5%

USUALLY THESE ERRORS ARE
ASSOCIATED WITH ATYPICAL IMAGES.

P. MACHADO, J. ROMERO, AND B. MANARIS, "EXPERIMENTS IN
COMPUTATIONAL AESTHETICS: AN ITERATIVE APPROACH TO
STYLISTIC CHANGE IN EVOLUTIONARY ART," IN THE ART OF
ARTIFICIAL EVOLUTION: A HANDBOOK ON EVOLUTIONARY ART
AND MUSIC, SPRINGER BERLIN HEIDELBERG, 2007, PP.
381-415.

ADVERSARIAL SYSTEMS

IDENTIFYING ATYPICAL IMAGES

THROUGHOUT THE ITERATIVE PROCESS
THE ANN ATTAINS SUCCESS RATES
ABOVE 99.5%

USUALLY THESE ERRORS ARE
ASSOCIATED WITH ATYPICAL IMAGES.

P. MACHADO, J. ROMERO, AND B. MANARIS, "EXPERIMENTS IN
COMPUTATIONAL AESTHETICS: AN ITERATIVE APPROACH TO
STYLISTIC CHANGE IN EVOLUTIONARY ART," IN THE ART OF
ARTIFICIAL EVOLUTION: A HANDBOOK ON EVOLUTIONARY ART
AND MUSIC, SPRINGER BERLIN HEIDELBERG, 2007, PP.
381-415.

ADVERSARIAL SYSTEMS

SAME BASE IDEA

ARCHIVE

FEASIBLE-UNFEASIBLE EVOLUTIONARY
MODEL

J. CORREIA, P. MACHADO, J. ROMERO, P. MARTINS, AND A.
CARDOSO, "BREAKING THE MOULD AN EVOLUTIONARY QUEST
FOR INNOVATION THROUGH STYLE CHANGE," IN
COMPUTATIONAL CREATIVITY - THE PHILOSOPHY AND
ENGINEERING OF AUTONOMOUSLY CREATIVE SYSTEMS, 1
ED., N/A: SPRINGER, 2019, VOL. 1, PP. 353-398.

DEEP INTERACTIVE EC

USE THE TRAINED GENERATOR PART OF
A GAN AS GENOTYPE-TO-PHENOTYPE
MAPPING, ALLOWING FOR
CONTROLLABLE HIGH-QUALITY IMAGE
GENERATION.

BONTRAGER, P., LIN, W., TOGELIUS, J., & RISI, S. (2018).
DEEP INTERACTIVE EVOLUTION. IN COMPUTATIONAL
INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN (PP. 267-
282). SPRINGER INTERNATIONAL PUBLISHING.

GANBREEDER

[HTTPS://GANBREEDER.APP/](https://ganbreeder.app/)

[HTTPS://GITHUB.COM/JOEL-SIMON/GANBREEDER](https://github.com/joel-simon/ganbreeder)
JOEL SIMON, 2018

INTERACTION

SEAMLESS INTERACTION
DESIGNING FITNESS FUNCTIONS

SEAMLESS INTERACTION

SOME SYSTEMS PROMOTE A SEAMLESS INTERACTION

USUALLY INVOLVES USING SENSORS TO CAPTURE INFORMATION FROM THE ENVIRONMENT (E.G. USER PRESENCE, MOVEMENT, PROXIMITY, ETC.)

TYPICAL APPLICATIONS INCLUDE PHYSICAL ART INSTALLATIONS

A-LIFE METAPHORS ARE POPULAR

EARLY EXAMPLES INCLUDE THE WORK OF KARL SIMS, MAURO ANNUNZIATO, ALAN DORIN, JOHN MCCORMACK, ETC.

PLANCTON ART STUDIO. "RELAZIONI EMERGENTI: EXPERIMENTS WITH ART OF EMERGENCE." LEONARDO 35, NO. 2 (APRIL 2002): 147-152.

SEAMLESS INTERACTION

PORTRAITS OF NO ONE

T. MARTINS, J. CORREIA, S. REBELO, J. BICKER, AND P. MACHADO, "PORTRAITS OF NO ONE: AN INTERACTIVE INSTALLATION," IN ARTIFICIAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN, CHAM, 2020, PP. 104-117.

DESIGNING FITNESS FUNCTIONS

PHOTOGROWTH

P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "AN INTERFACE FOR FITNESS FUNCTION DESIGN," EVOMUSART 2014, GRANADA, SPAIN, APRIL 23-25, 2014. PROCEEDINGS, 2014.

DESIGNING FITNESS FUNCTIONS

ANTS' SIMULATION

THE ANTS LIVE IN A 2D ENVIRONMENT. THEY MOVE, GAIN AND LOSE ENERGY, GENERATE OFFSPRING AND DIE.

THEY HAVE SENSORY ORGANS THAT DETECT LIGHT.

LIGHT = ENERGY

MOVEMENT IS DETERMINED BY THE SENSORY ORGANS

WHILE THEY MOVE THEY PAINT ON A PAINTING CANVAS.

THE COLOR IS DETERMINED AT BIRTH.

THE WIDTH IS PROPORTIONAL TO THE ENERGY.

P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "AN INTERFACE FOR FITNESS FUNCTION DESIGN," EVOMUSART 2014, GRANADA, SPAIN, APRIL 23-25, 2014. PROCEEDINGS, 2014.

DESIGNING FITNESS FUNCTIONS

USER DEFINED FITNESS

RESPONSIVE INTERFACE TO CREATE FITNESS FUNCTIONS BASED ON IMAGE AND BEHAVIORAL FEATURES.

P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "AN INTERFACE FOR FITNESS FUNCTION DESIGN," EVOMUSART 2014, GRANADA, SPAIN, APRIL 23-25, 2014. PROCEEDINGS, 2014.

DESIGNING FITNESS FUNCTIONS

EVOLVED ANT PAINTINGS

WE ASKED A USER TO CREATE FIVE DIFFERENT FITNESS FUNCTIONS.

WE CONDUCTED TEN EVOLUTIONARY RUNS FOR EACH OF THESE FUNCTIONS.

ONCE THESE RUNS WERE FINALIZED THE USER REVIEWED THE RESULTS, SELECTED HIS FAVORITE INDIVIDUALS.

DESIGNING FITNESS FUNCTIONS

EVOLVED ANT PAINTINGS

WE ASKED A USER TO CREATE FIVE DIFFERENT FITNESS FUNCTIONS.

WE CONDUCTED TEN EVOLUTIONARY RUNS FOR EACH OF THESE FUNCTIONS.

ONCE THESE RUNS WERE FINALIZED THE USER REVIEWED THE RESULTS, SELECTED HIS FAVORITE INDIVIDUALS.

WE ASKED TO DESIGN AN ADDITIONAL SET OF FIVE FITNESS FUNCTIONS.

THIS PROCESS WAS REPEATED ITERATIVELY RESULTING IN A TOTAL OF 15 FITNESS FUNCTIONS AND 150 EVOLUTIONARY RUNS.

DESIGNING FITNESS FUNCTIONS

EVOLVED ANT PAINTINGS

WE ASKED A USER TO CREATE FIVE DIFFERENT FITNESS FUNCTIONS.

WE CONDUCTED TEN EVOLUTIONARY RUNS FOR EACH OF THESE FUNCTIONS.

ONCE THESE RUNS WERE FINALIZED THE USER REVIEWED THE RESULTS, SELECTED HIS FAVORITE INDIVIDUALS.

WE ASKED TO DESIGN AN ADDITIONAL SET OF FIVE FITNESS FUNCTIONS.

THIS PROCESS WAS REPEATED ITERATIVELY RESULTING IN A TOTAL OF 15 FITNESS FUNCTIONS AND 150 EVOLUTIONARY RUNS.

DESIGNING FITNESS FUNCTIONS

GENERALIZATION

ONE OF THE KEY ASPECTS OF OUR APPROACH IS THE ABILITY TO APPLY SELECTED GENOTYPES TO DIFFERENT INPUT IMAGES.

P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "AN INTERFACE FOR FITNESS FUNCTION DESIGN," EVOMUSART 2014, GRANADA, SPAIN, APRIL 23-25, 2014. PROCEEDINGS, 2014.

BIBLIOGRAPHY

- [1] F. ASSUNÇÃO, J. CORREIA, P. MARTINS, AND P. MACHADO, "EVOLVING FAMILIES OF SHAPES," IN PROCEEDINGS OF THE TWENTY-FOURTH INTERNATIONAL JOINT CONFERENCE ON ARTIFICIAL INTELLIGENCE, IJCAI 2015, BUENOS AIRES, ARGENTINA, JULY 25-31, 2015, PP. 4134-4136.
- [2] S. BALAJIA, D. POMERLEAU, J. TODD, TOWARDS AUTOMATED ARTIFICIAL EVOLUTION FOR COMPUTER-GENERATED IMAGES. CONNECTION SCIENCE 1894, 6(2):325-34
- [3] P. BONTRAGER, W. LIN, J. TOGELUS AND S. RISI, "DEEP INTERACTIVE EVOLUTION," IN COMPUTATIONAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN (PP. 267-282), 2018.
- [4] E. BAKER, M. SELTZER, "EVOLVING LINE DRAWINGS", HARVARD COMPUTER SCIENCE GROUP TECHNICAL REPORT TR-21-93, 1993.
- [5] J. CORREIA, P. MACHADO, J. ROMERO, AND A. CARBALLAL, "EVOLVING FIGURATIVE IMAGES USING EXPRESSION-BASED EVOLUTIONARY ART," IN PROCEEDINGS OF THE FOURTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY (ICCC), 2013, PP. 24-31.
- [6] J. CORREIA, T. MARTINS, P. MARTINS, AND P. MACHADO, "X-FACES: THE EXPLOIT IS OUT THERE," IN PROCEEDINGS OF THE SEVENTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY (ICCC 2016), 2016, PP. 184-192.
- [7] J. CORREIA, T. MARTINS, AND P. MACHADO, "EVOLUTIONARY DATA AUGMENTATION IN DEEP FACE DETECTION," IN GECCO 2019 - PROCEEDINGS OF THE 2019 GENETIC AND EVOLUTIONARY COMPUTATION CONFERENCE, PRAGUE, CZECH REPUBLIC, 2019.
- [8] J. CORREIA, P. MACHADO, J. ROMERO, P. MARTINS, AND A. CARDOSO, "BREAKING THE MOULD AN EVOLUTIONARY QUEST FOR INNOVATION THROUGH STYLE CHANGE," IN COMPUTATIONAL CREATIVITY - THE PHILOSOPHY AND ENGINEERING OF AUTONOMOUSLY CREATIVE SYSTEMS, 1 ED., M/A: SPRINGER, 2019, VOL. 1, PP. 393-398.
- [9] J. CORREIA, L. VIEIRA, N. RODRIGUEZ-FERNANDEZ, J. ROMERO, AND P. MACHADO, "EVOLVING IMAGE ENHANCEMENT PIPELINES," IN ARTIFICIAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN, CHAM, 2021, PP. 82-87.
- [10] J. M. CUNHA, N. LOURENÇO, J. CORREIA, P. MARTINS, AND P. MACHADO, "EMOJINATING: EVOLVING EMOJI BLENDS," IN COMPUTATIONAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN - 8TH INTERNATIONAL CONFERENCE, EVOMUSART 2019, HELD AS PART OF EVOSTAR 2019, LEIPZIG, GERMANY, APRIL 24-26, 2019, PROCEEDINGS, 2019, PP. 110-126.
- [11] J. M. CUNHA, P. MARTINS, AND P. MACHADO, "EVER-CHANGING FLAGS: IMPACT AND ETHICS OF MODIFYING NATIONAL SYMBOLS," IN PROCEEDINGS OF THE ELEVENTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY, ICCO 2020, COIMBRA, PORTUGAL, SEPTEMBER 7-11, 2020, 2020, PP. 410-413.
- [12] E. DEN HEIJER AND A. E. EIBEN, "EVOLVING POP ART USING SCALABLE VECTOR GRAPHICS", IN PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN. SPRINGER-VERLAG, BERLIN, HEIDELBERG, 48-59, 2012.
- [13] S. DRAVES, "EVOLUTION AND COLLECTIVE INTELLIGENCE OF THE ELECTRIC SHEEP," THE ART OF ARTIFICIAL EVOLUTION, 2008.
- [14] F. GRACA AND P. MACHADO, "EVOLVING ASSEMBLAGES," IJART, VOL. 9, ISS. 2, PP. 167-184, 2015.
- [15] G. GREENFIELD AND P. MACHADO, "SWARMART: CURATOR'S INTRODUCTION," LEONARDO, VOL. 47, ISS. 1, PP. 5-7, 2014.
- [16] G. GREENFIELD AND P. MACHADO, "ANT- AND ANT-COLONY-INSPIRED ALIEN VISUAL ART," ARTIFICIAL LIFE, VOL. 21, ISS. 3, PP. 293-306, 2015.
- [17] J. HELMS, J. CLUNE, "IMPROVING HYBRID: HOW TO BEST COMBINE INDIRECT AND DIRECT ENCODING IN EVOLUTIONARY ALGORITHMS," PLOS ONE 12(3): E0174635. <https://doi.org/10.1371/JOURNAL.PONE.0174635>, 2017.
- [18] D. LOPES, J. CORREIA, AND P. MACHADO, "IDEA - EVOLVING GLYPHS FOR AIDING CREATIVITY IN TYPEFACE DESIGN," IN PROCEEDINGS OF THE 2020 GENETIC AND EVOLUTIONARY COMPUTATION CONFERENCE COMPANION, NEW YORK, NY, USA, 2020, PP. 97-99.
- [19] N. LOURENÇO, F. ASSUNÇÃO, C. MACÁS, AND P. MACHADO, "EVOFASHION: CUSTOMISING FASHION THROUGH EVOLUTION," IN INTERNATIONAL CONFERENCE ON EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC AND ART, 2017.
- [20] C. MACÁS, N. LOURENÇO, AND P. MACHADO, "INTERACTIVE EVOLUTION OF SWARMS FOR THE VISUALISATION OF CONSUMPTIONS," IN INTERACTIVITY, GAME CREATION, DESIGN, LEARNING, AND INNOVATION - 7TH EAI INTERNATIONAL CONFERENCE, ARTIST 2018, AND 3RD EAI INTERNATIONAL CONFERENCE, DLI 2018, ICTCC 2018, BRAGA, PORTUGAL, OCTOBER 24-26, 2018, PROCEEDINGS, 2018, PP. 101-110.
- [21] C. MACÁS, N. LOURENÇO, AND P. MACHADO, "EVOLVING VISUAL ARTIFACTS BASED ON CONSUMPTION PATTERNS," INTERNATIONAL JOURNAL OF ARTS AND TECHNOLOGY, VOL. 12, ISS. 1, P. 60, 2020.
- [22] P. MACHADO AND A. CARDOSO, "COMPUTING AESTHETICS," IN ADVANCES IN ARTIFICIAL INTELLIGENCE, 14TH BRAZILIAN SYMPOSIUM ON ARTIFICIAL INTELLIGENCE, SBIA'98, PORTO ALEGRE, BRAZIL, NOVEMBER 4-6, 1998, PROCEEDINGS, 1998, PP. 219-228.
- [23] P. MACHADO AND A. CARDOSO, "NEVAR - THE ASSESSMENT OF AN EVOLUTIONARY ART TOOL," IN AISB'00 SYMPOSIUM ON CREATIVE AND CULTURAL ASPECTS AND APPLICATIONS OF AI AND COGNITIVE SCIENCE, BIRMINGHAM, UK, 2000.
- [24] P. MACHADO, A. DIAS, AND A. CARDOSO, "LEARNING TO COLOUR GREYSCALE IMAGES," THE INTERDISCIPLINARY JOURNAL OF ARTIFICIAL INTELLIGENCE AND THE SIMULATION OF BEHAVIOUR - AISB JOURNAL, VOL. 1, ISS. 2, PP. 209-219, 2002.

BIBLIOGRAPHY

- [25] P. MACHADO, J. ROMERO, B. MAMARIS, A. SANTOS, AND A. CARDOSO, "POWER TO THE CRITICS — A FRAMEWORK FOR THE DEVELOPMENT OF ARTIFICIAL ART CRITICS," IN LICA! 2003 WORKSHOP ON CREATIVE SYSTEMS, ACAPULCO, MEXICO, 2003.P. MACHADO AND A. CARDOSO, "ALL THE TRUTH ABOUT NEVAR," APPLIED INTELLIGENCE, SPECIAL ISSUE ON CREATIVE SYSTEMS, VOL. 16, ISS. 2, PP. 101–119, 2002.
- [26] P. MACHADO, J. ROMERO, M. L. SANTOS, A. CARDOSO, AND B. Z. MAMARIS, "ADAPTIVE CRITICS FOR EVOLUTIONARY ARTISTS," IN APPLICATIONS OF EVOLUTIONARY COMPUTING, EVOWORKSHOPS 2004: EVOBIO, EVOCOMNET, EVONOT, EVOIASP, EVOMUSART, AND EVOSTOC, COIMBRA, PORTUGAL, APRIL 5–7, 2004, PROCEEDINGS, 2004, PP. 437–446.
- [27] P. MACHADO, J. ROMERO, A. CARDOSO, AND A. SANTOS, "PARTIALLY INTERACTIVE EVOLUTIONARY ARTISTS," NEW GENERATION COMPUTING — SPECIAL ISSUE ON INTERACTIVE EVOLUTIONARY COMPUTATION, VOL. 23, ISS. 42, PP. 143–155, 2005.
- [28] P. MACHADO, J. ROMERO, A. SANTOS, A. CARDOSO, AND A. PAZOS, "ON THE DEVELOPMENT OF EVOLUTIONARY ARTIFICIAL ARTISTS," COMPUTERS & GRAPHICS, VOL. 31, ISS. 6, PP. 818–826, 2007.
- [29] P. MACHADO, J. ROMERO, AND B. MAMARIS, "EXPERIMENTS IN COMPUTATIONAL AESTHETICS: AN ITERATIVE APPROACH TO STYLISTIC CHANGE IN EVOLUTIONARY ART," IN THE ART OF ARTIFICIAL EVOLUTION: A HANDBOOK ON EVOLUTIONARY ART AND MUSIC, J. ROMERO AND P. MACHADO, EDS., SPRINGER BERLIN HEIDELBERG, 2007, PP. 381–415.
- [30] P. MACHADO, H. NUNES, AND J. ROMERO, "GRAPH-BASED EVOLUTION OF VISUAL LANGUAGES," IN APPLICATIONS OF EVOLUTIONARY COMPUTATION, EVOAAPPLICATIONS 2010: EVOCOMNET, EVONENVIRONMENT, EVOFIN, EVOMUSART, AND EVOTRANSLUG, ISTANBUL, TURKEY, APRIL 7–9, 2010, PROCEEDINGS, PART II, 2010, PP. 227–230.
- [31] P. MACHADO, J. CORREIA, AND J. ROMERO, "EXPRESSION-BASED EVOLUTION OF FACES," IN EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN — FIRST INTERNATIONAL CONFERENCE, EVOMUSART 2012, MÁLAGA, SPAIN, APRIL 11–13, 2012. PROCEEDINGS, 2012, PP. 187–198.
- [32] P. MACHADO AND H. AMARO, "FITNESS FUNCTIONS FOR ANT COLONY PAINTINGS," IN PROCEEDINGS OF THE FOURTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY (CCC), 2013, PP. 32–39.
- [33] P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "AN INTERFACE FOR FITNESS FUNCTION DESIGN," IN EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN — THIRD INTERNATIONAL CONFERENCE, EVOMUSART 2014, GRÁNADA, SPAIN, APRIL 22–25, 2014. PROCEEDINGS, 2014.
- [34] P. MACHADO, A. VINHAS, J. CORREIA, AND A. EXÁRT, "EVOLVING AMBIGUOUS IMAGES," IN PROCEEDINGS OF THE TWENTY-FOURTH INTERNATIONAL JOINT CONFERENCE ON ARTIFICIAL INTELLIGENCE, LICA! 2015, BUENOS AIRES, ARGENTINA, JULY 26–31, 2015, 2015, PP. 2473–2479.
- [35] P. MACHADO, J. CORREIA, AND F. ASSUNÇÃO, "GRAPH-BASED EVOLUTIONARY ART," IN HANDBOOK OF GENETIC PROGRAMMING APPLICATIONS, A. H. GANDOMI, A. H. ALAVI, AND C. RYAN, EDS., CHAM: SPRINGER INTERNATIONAL PUBLISHING, 2015, PP. 3–36.
- [36] P. MACHADO, T. MARTINS, H. AMARO, AND P. H. ABREU, "BEYOND INTERACTIVE EVOLUTION: EXPRESSING INTENTIONS THROUGH FITNESS FUNCTIONS," LEONARDO, VOL. 49, ISS. 3, PP. 261–265, 2016.
- [37] B. Z. MAMARIS, P. MACHADO, C. MCCOLEY, J. ROMERO, AND D. KREIBEL, "DEVELOPING FITNESS FUNCTIONS FOR PLEASANT MUSIC, ZEP'S LAW AND INTERACTIVE EVOLUTION SYSTEMS," IN APPLICATIONS OF EVOLUTIONARY COMPUTING, EVOWORKSHOPS 2005: EVOBIO, EVOCOMNET, EVONOT, EVOIASP, EVOMUSART, AND EVOSTOC, LAUSANNE, SWITZERLAND, MARCH 30 – APRIL 1, 2005, PROCEEDINGS, 2005, PP. 498–507.
- [38] T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOTYPE: EVOLUTIONARY TYPE DESIGN," IN EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN — 4TH INTERNATIONAL CONFERENCE, EVOMUSART 2015, COPENHAGEN, DENMARK, APRIL 8–10, 2015, PROCEEDINGS, 2015, PP. 136–147.
- [39] T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOTYPE: FROM SHAPES TO GLYPHS," IN PROCEEDINGS OF THE GENETIC AND EVOLUTIONARY COMPUTATION CONFERENCE 2016, NEW YORK, NY, USA, 2016, PP. 261–268.
- [40] T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOTYPE: TOWARDS THE EVOLUTION OF TYPE STENCILS," IN COMPUTATIONAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN, CHAM, 2018, PP. 299–314.
- [41] T. MARTINS, S. REBELO, J. BICKER, AND P. MACHADO, "BUILDING TYPEFACES AS PROGRAMS: A NODE-BASED APPROACH FOR MODULAR TYPE DESIGN," IN NINTH TYPOGRAPHY MEETING (SET) — BOOK OF PROCEEDINGS, TORONTO, PORTUGAL, 2019, PP. 64–78.
- [42] T. MARTINS, J. CORREIA, E. COSTA, AND P. MACHADO, "EVOLVING STENCILS FOR TYPEFACES: COMBINING MACHINE LEARNING, USER'S PREFERENCES AND NOVELTY," COMPLEXITY, VOL. 2019, 2019.
- [43] T. MARTINS, J. CORREIA, S. REBELO, J. BICKER, AND P. MACHADO, "PORTRAITS OF NO ONE: AN INTERACTIVE INSTALLATION," IN ARTIFICIAL INTELLIGENCE IN MUSIC, SOUND, ART AND DESIGN, CHAM, 2020, PP. 104–117.
- [44] T. MARTINS, J. CORREIA, S. REBELO, J. BICKER, AND P. MACHADO, "PORTRAITS OF NO ONE: AN INTERNET ARTWORK," IN PROCEEDINGS OF THE 28TH ACM INTERNATIONAL CONFERENCE ON MULTIMEDIA, NEW YORK, NY, USA, 2020, P. 4392–4393.
- [45] A. NOUYEY, J. YOSINSKI, J. CLUNE, "DEEP NEURAL NETWORKS ARE EASILY FOOLED: HIGH CONFIDENCE PREDICTIONS FOR UNRECOGNIZABLE IMAGES," IN COMPUTER VISION AND PATTERN RECOGNITION (CVPR '16), IEEE, 2016.
- [46] S. REBELO, C. PIRES, P. MARTINS, J. BICKER, AND P. MACHADO, "DESIGNING POSTERS TOWARDS A SEAMLESS INTEGRATION IN URBAN SURROUNDINGS: A COMPUTATIONAL APPROACH," IN PROCEEDINGS OF THE 9TH INTERNATIONAL CONFERENCE ON DIGITAL AND INTERACTIVE ARTS, NEW YORK, NY, USA, 2019.

BIBLIOGRAPHY

- [47] S. REBELO, J. BICKER, AND P. MACHADO, "EVOLUTIONARY EXPERIMENTS IN TYPESETTING OF LETTERPRESS-INSPIRED POSTERS," IN PROCEEDINGS OF THE ELEVENTH INTERNATIONAL CONFERENCE ON COMPUTATIONAL CREATIVITY, SEPTEMBER 7–11, 2020, 2020.
- [48] J. ROMERO, P. MACHADO, A. SANTOS, AND A. CARDOSO, "ON THE DEVELOPMENT OF CRITICS IN EVOLUTIONARY COMPUTATION ARTISTS," IN APPLICATIONS OF EVOLUTIONARY COMPUTING, EVOWORKSHOP 2003: EVOBIO, EVOCOP, EVOIASP, EVOMUSART, EVOROB, AND EVOSTIM, ESSEX, UK, APRIL 14–16, 2003, PROCEEDINGS, 2003, PP. 559–569.
- [49] J. ROMERO, P. MACHADO, A. CARBALLAL, AND D. OSORIO, "AESTHETIC CLASSIFICATION AND SORTING BASED ON IMAGE COMPRESSION," IN APPLICATIONS OF EVOLUTIONARY COMPUTATION – EVOAPPLICATIONS 2011: EVOCOMNET, EVOFIN, EVONOT, EVOMUSART, EVOSTIM, AND EVOTRANSLUG, TORINO, ITALY, APRIL 27–29, 2011, PROCEEDINGS, PART I, 2011, PP. 364–403.
- [50] J. ROMERO, P. MACHADO, A. CARBALLAL, AND A. SANTOS, "USING COMPLEXITY ESTIMATES IN AESTHETIC IMAGE CLASSIFICATION," JOURNAL OF MATHEMATICS AND THE ARTS, VOL. 6, ISS. 2–3, PP. 125–136, 2012.
- [51] J. SECRETAN, N. BEATO, D. B. D. AMBROSIO, A. RODRIGUEZ, A. CAMPBELL, AND K. O. STANLEY, 2008. PICBREEDER: EVOLVING PICTURES COLLABORATIVELY ONLINE. IN PROCEEDINGS OF THE SIGCHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS (CHI '08). ACM, NEW YORK, NY, USA, 1759–1768.
- [52] K. SIMS, "ARTIFICIAL EVOLUTION FOR COMPUTER GRAPHICS," SIGGRAPH '91 PROCEEDINGS: 319–320, 1991.
- [53] S. TODD AND W. LATHAM, "EVOLUTIONARY ART AND COMPUTERS," 1992.
- [54] J. VENTRELLA, "DISNEY MEETS DARWIN: AN EVOLUTION-BASED INTERFACE FOR EXPLORATION AND DESIGN OF EXPRESSIVE ANIMATED BEHAVIOR", THESIS (M.S.), MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1994.
- [55] A. VINHAS, F. ASSUNÇÃO, J. CORREIA, A. EXÁRT, AND P. MACHADO, "FITNESS AND NOVELTY IN EVOLUTIONARY ART," IN EVOLUTIONARY AND BIOLOGICALLY INSPIRED MUSIC, SOUND, ART AND DESIGN — 5TH INTERNATIONAL CONFERENCE, EVOMUSART 2016, PORTO, PORTUGAL, MARCH 09 – APRIL 1, 2016, PROCEEDINGS, 2016, PP. 225–240.
- [56] P. XIAO, H. TUOVONEN, D. GROSS, A. CARDOSO, J. CORREIA, P. MACHADO, P. MARTINS, H. G. OLIVEIRA, R. SHARMA, A. M. PIETRO, A. DIÁZ, V. FRANCISCO, P. GERVÁS, R. HERVÁS, C. LEÓN, J. FORTH, M. PURVER, G. A. WIGGINS, D. MIL-KOJIC, V. POPPEČAN, S. POLLAJ, J. KRALJ, M. ŽNIDARŠIČ, M. BOHANEČ, N. LAVRAC, T. URBANČIČ, F. V. D. VELDE, AND S. BATTERSBY, "CONCEPTUAL REPRESENTATIONS FOR COMPUTATIONAL CONCEPT CREATION," ACM COMPUTING SURVEYS, VOL. 52, ISS. 1, P. 9:1–9:33, 2019.

SEE ALSO

[HTTPS://EVOMUSART-INDEX.DEI.UC.PT/](https://evomusart-index.dei.uc.pt/)

EvoMUSART index / Authors / Keywords / Years / Info / EvoMUSART 2021			
A Deep Learning Neural Network for Classifying Good and Bad Photos	Stephen Lou Baral / Vic Ciesielski	Deep Learning / Aesthetics / Photography	2020
Adapting and Enhancing Evolutionary Art for Casual Creation	Simon Colton / Jon McCormack / Sebastian Berne / Elena Petrovskaya / Michael Cook		2020
An Aesthetic-Based Fitness Measure and a Framework for Guidance of Evolutionary Design in Architecture	Manuel Muthbauer / Jana Burry / Andy Song	Evolutionary Computation / Architectural Design / Grammar Evolution / Fitness Evolution	2020
Coevolving Artistic Images Using OMNI-REP	Mothe Sipper / Jason H. Moore / Ryan J. Urbanowicz	Evolutionary Algorithms / Evolutionary Art / Cooperative Coevolution / Interpretation	2020
Comparing Fuzzy Rule Based Approaches for Music Genre Classification	Frederik Heerde / Igor Valokhin / Günter Rudolph	Fuzzy Rule Based / Music Genre Recognition / Semantic Features	2020
Controlling Self-organization in Generative Creative Systems	Jonathan Young / Simon Colton	Artificial Chemistry / Artificial Life / Generative Creativity / Unsupervised Learning / Guided Self-Organization	2020
Emerging Technology System Evolution	Matthew Lewis	Emerging Technologies / Creative Systems / Interactive Evolution	2020
Emulation Games	Augusto Zubiega / Lourdes Cilleruelo	Emulation Game / Computational Neuroscience / Epigenetics	2020
Fusion of Hilbert-Huang Transform and Deep Convolutional Neural Network for Predominant Musical Instruments Recognition	Xiaoquan Li / Kaiqi Wang / John Sorenghan / Jinchang Ren	Predominant Musical Instrument Recognition / Convolutional Neural Network / Hilbert-Huang Transform	2020
Genetic Reweb: Synthesizing Artificial Rewebmaster Fillets via Genetic Algorithms	Edward Ly / Julian Villegas	Convolution Reweb / Genetic Algorithms / Impulse Responses / Room Acoustics / Signal Processing	2020
Objective Evaluation of Tonal Fitness for Chord Progressions Using the Tonal Interval Space	Maria Navarro-Gilones / Marcelo Castano / Gilberto Bernardes	Chord Progression / Hierarchical Tension / Tonal Interval Space / Melodic Attraction / Consonance	2020
Portraits of No One: An Interactive Installation	Tiago Martins / João Correia / Sérgio Ribeiro / João Bicker / Pensuol Machado	Interactive Installation / Media Art / Artificial Intelligence / Computer Vision / Image Generation / Computer Graphics	2020
Quantum Zentanglement: Combining Procedural and Wave Function Collapse to Create Zentangles extraterrested	Anna Krokowicz / Sarah Friday / Alice Dourlens / Jacob Schrim	Zentangle / Compositional Pattern Producing Networks / Wave Function Collapse / Neuroevolution / Interactive Evolution	2020
Sound Cells in Genetic Improvisation: An Evolutionary Model for Improvised Music	Sebastian Thump	Evolutionary Algorithms / Musical Improvisation / Computational Analysis	2020
Understanding Aesthetic Evaluation Using Deep Learning	Jon McCormack / Andy Lomas	Evolutionary Art / Aesthetics / Aesthetic Measures / Convolutional Neural Networks / Dimension Reduction / Morphogenesis	2020
Adversarial Evolution and Deep Learning - How Does an Artist Play with Our Visual System?	Alan Blair	Evolutionary Art / AI-Generated Art / Anti-Critic Conclusion / Adversarial Training / Computational Creativity	2019
Automatic Jazz Melody Composition Through a Learning-Based Genetic Algorithm	Yong-Wook Nam / Yang-Hyuk Kim	Genetic Algorithm / Automatic Composing / Geometric Crossover	2019
Automatically Generating Engaging Presentation Slide Decks	Thomas Winters / Kory W. Mathewson	Computer-Aided and Computational Creativity / Generation / Computational Intelligence for Human Creativity	2019
Autonomy, Authenticity, Authorship and Intuition in Computer Generated Art	Jon McCormack / Toby Gifford / Patrick Hutchings	Autonomy / Authenticity / Computer Art / Aesthetics / Authorship	2019
Camera Observer: Generative Art for Design Inspiration	Dilpreet Singh / Nina Rajic / Simon Colton / Jon McCormack		2019
Comparing Models for Harmony Prediction in an Interactive Audio Looper	Benedikte Wallace / Charles P. Martin	RNN / Deep Learning / Music Interaction / Machine Improvisation	2019
Deep Learning Concepts for Evolutionary Art	Fazle Tariqi / Brian Ross	Deep Convolutional Neural Network / Genetic Programming / Evolutionary Art	2019
Eliminating Evolving Emoji Biends	João M. Cunha / Nuno Loureiro / João Correia / Pedro Martins / Pensuol Machado	Evolutionary Algorithms / Emoji / Interactive Evolutionary Computation / Visual Biends	2019