Creative Evolutionary Computation

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Tutorial Outline

- Can computational processes be **creative**?
- **Who** should judge and **what** should be critiqued?
- How can EC **help** such computational processes?
- How can EC **benefit** from comp. creativity?

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Introduction to Computational Creativity

Basic Notions and Definitions

- Ancient times: creativity treated as a quasi-mystical property, as an activity of the gods in us.
- Recent times: creativity everywhere.
  - **big-c creativity** (individualistic creativity of a genius)
  - **little-c creavity** (every-day, social creativity)
  - **historical creativity** (an idea that is new to the world)
  - **personal creativity** (an idea that is new to the person)

Plato. Ion. In E. Hamilton and H. Cairns, editors, Plato: The Collected Dialogues. Princeton University Press, 1961.

B. Jerey and A. Craft. The universalization of creativity. In A. Craft, B. Jerey, and M. Leibling, editors, Creativity in Education. 2001.

M. A. Boden. The creative mind: Myths and mechanisms. Routledge, 2003.

Basic Notions and Definitions

- **Creative Emotive Reasoning:**
  - Lateral thinking *(thinking outside the box)*
  - Diagrammatic reasoning *(understanding data via diagrams)*
  - Visual and analogical lateral thinking.
  - **Frames:** a routine for tasks, a pattern of associations.
  - **Intervention** that **disrupts** a frame, resulting in **re-framing**.
- **Wise Humanizing Creativity:**
  - Reference to a shared value system.

E. De Bono. Lateral thinking: Creativity step by step. Harper Collins, 2010.

T. Scaltsas and C. Alexopoulos. Creating creativity through emotive thinking. In Proceedings of the World Congress of Philosophy, 2013.

K. Chappell, A. R. Craft, L. Rolfe, and V. Jobbins. Humanizing creativity: Valuing our journeys of becoming. International Journal of Education & the Arts, 13(8), 2012.

What is Computational Creativity?

"Computational Creativity is the art, science, philosophy and engineering of computational systems which, by taking on particular responsibilities, exhibit behaviors that unbiased observers would deem to be creative."

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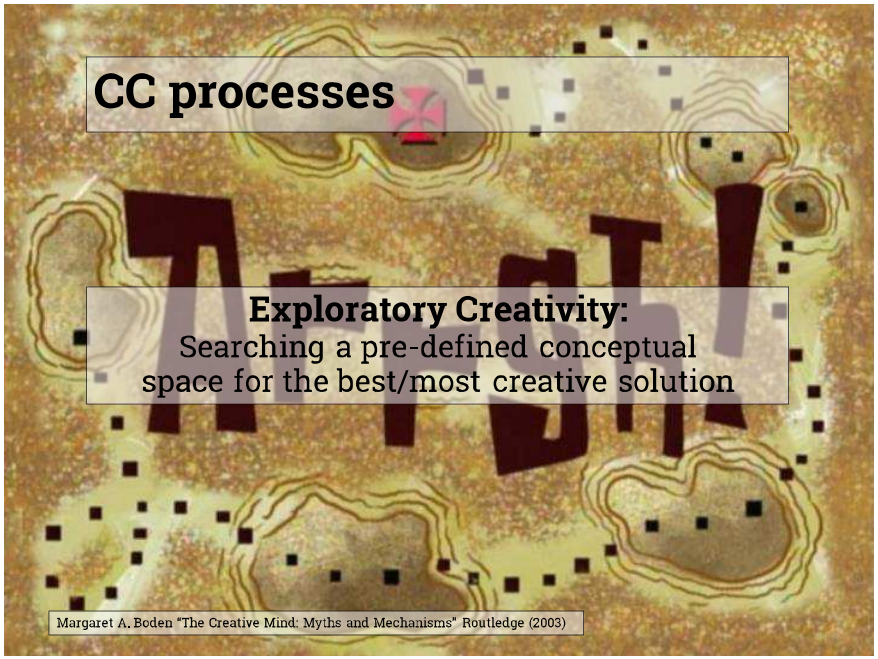
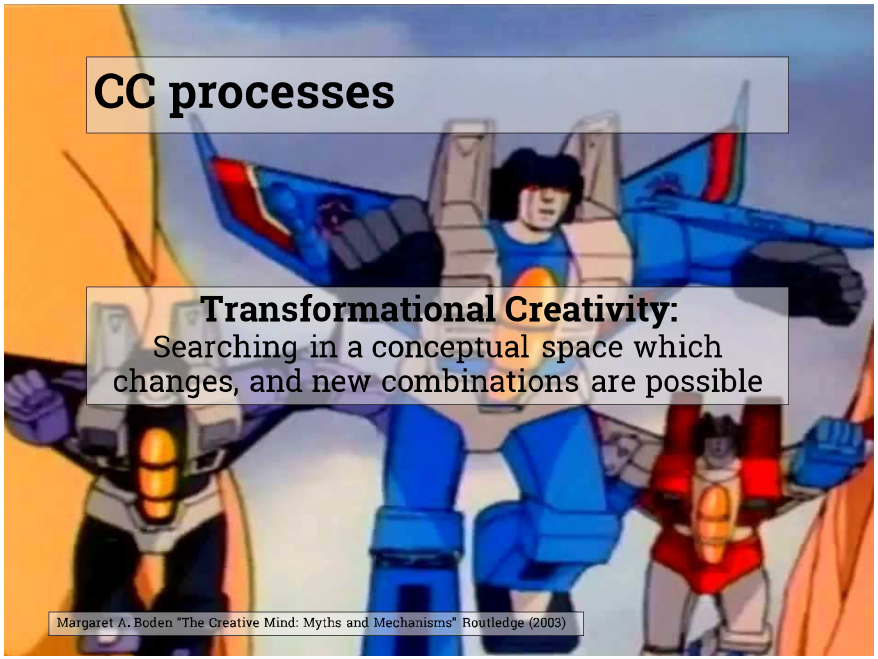


CC processes

Combinatorial Creativity:
Pre-fabricated building blocks, combined together in unexpected ways

Margaret A. Boden "The Creative Mind: Myths and Mechanisms" Routledge (2003)



CC processes

Transformational Creativity:
Searching in a conceptual space which changes, and new combinations are possible

Margaret A. Boden "The Creative Mind: Myths and Mechanisms" Routledge (2003)

CC outcomes

- **Novelty:** To what extent is the produced item dissimilar to existing examples of its genre?
- **Quality:** To what extent is the produced item a high quality example of its genre?
- **Typicality:** To what extent is the produced item an example of the artefact class in question?

Graeme Ritchie: "Some empirical criteria for attributing creativity to a computer program". Minds and Machines 17:76–99. 2007

Domains of CC

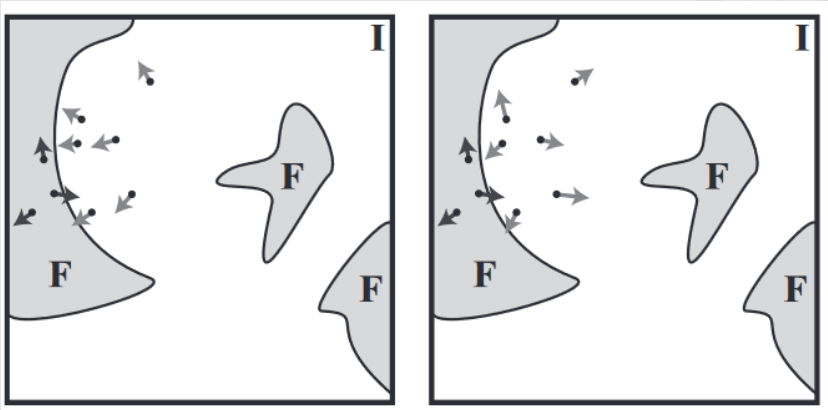
- Poetry, Analogies, Storytelling, Jokes
- Images, Music, Videos,
- Digital Games: rules, levels, plots
- Mathematical and Algorithmic Discovery

Artificial Evolution for Computational Creativity

Why is evolution ideal for CC?

Computational Creativity	**EC**
• Combinatorial Creativity	✓
• Exploratory Creativity	✓ ✓ ✓ ✓ ✓
• Transformational Creativity	✓

Value, Novelty and Surprise



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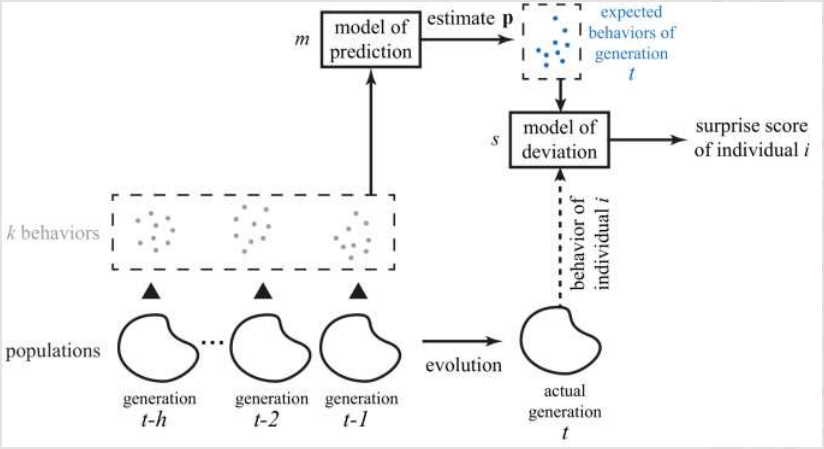
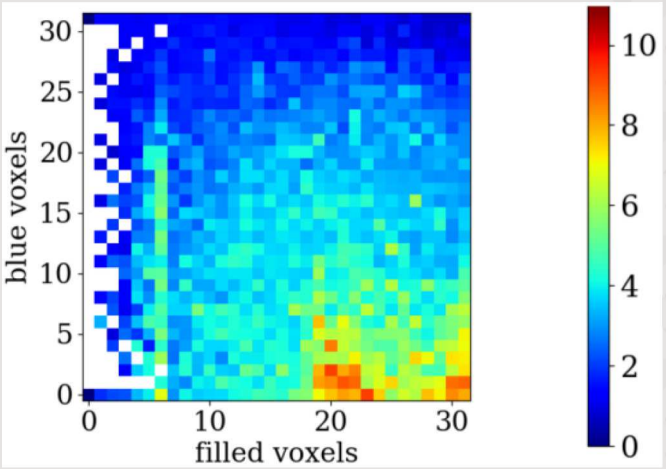
Value, Novelty and Surprise



Daniele Gravina, Antonios Liapis and Georgios N. Yannakakis: "Quality Diversity Through Surprise," in Transactions on Evolutionary Computation, 2019.

Value, Novelty and Surprise



Daniele Gravina, Antonios Liapis and Georgios N. Yannakakis: "Blending Notions of Diversity for MAP-Elites," In Proceedings of the Genetic and Evolutionary Computation Conference, 2017.

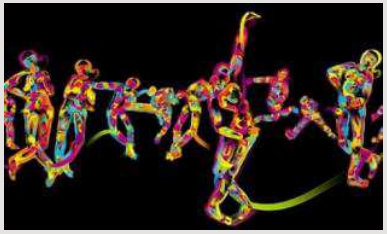
Core Domains of CC via evolution

Problem Solving

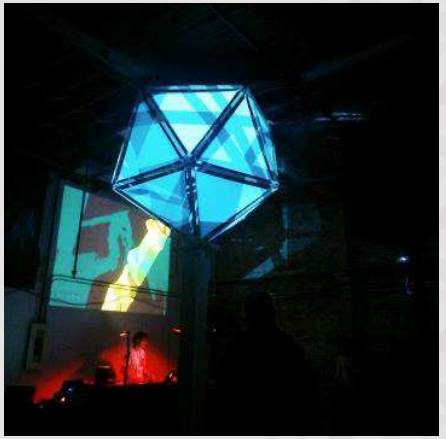
- Example domain: **maze navigation**
- Driven by surprise, novelty, or a combination

Daniele Gravina, Antonios Liapis and Georgios N. Yannakakis: "Quality Diversity Through Surprise," in Transactions on Evolutionary Computation, 2019.

Art & Music



Mauro Annunziato, The Nagual Experiment, digital image, 1998
Robot painter draws on abstract thoughts, The Guardian, 2012.
Algorave – ISEA 2015 curator: Philippe Pasquier, Metacreation Lab

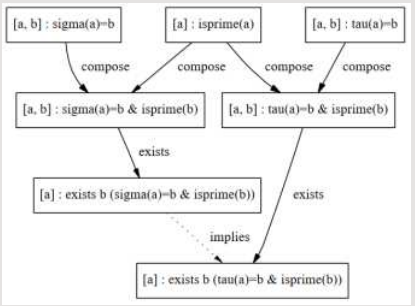


Digital Games

- **Are games a creative domain?**
  - they fall into a large class (possibly with subclasses, e.g. casual, shooter, RPG)
  - this class has somewhat fuzzy boundaries.
  - this class has extensive human-based evaluations of quality.

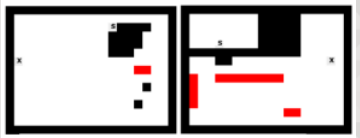
Math & Algorithmic Discovery

Michael Cook, Simon Colton, Azalea Raad, and Jeremy Gow, "Mechanic Miner: Reflection-Driven Game Mechanic Discovery and Level Design" EvoApplications 2013: Applications of Evolutionary Computation pp 284-293, 2013.

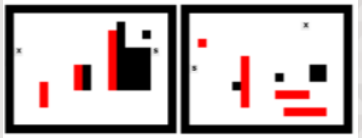


Simon Colton: Automated Conjecture Making In Number Theory Using HR, Otter and Maple In: Journal of Symbolic Computation, 39 (5), pp. 593–615, 2005.

```
if(specialButtonPressed){
    if(triggeredOn)
        someVariable += someValue;
    else
        someVariable -= someValue;
    triggeredOn = !triggeredOn;
}
```



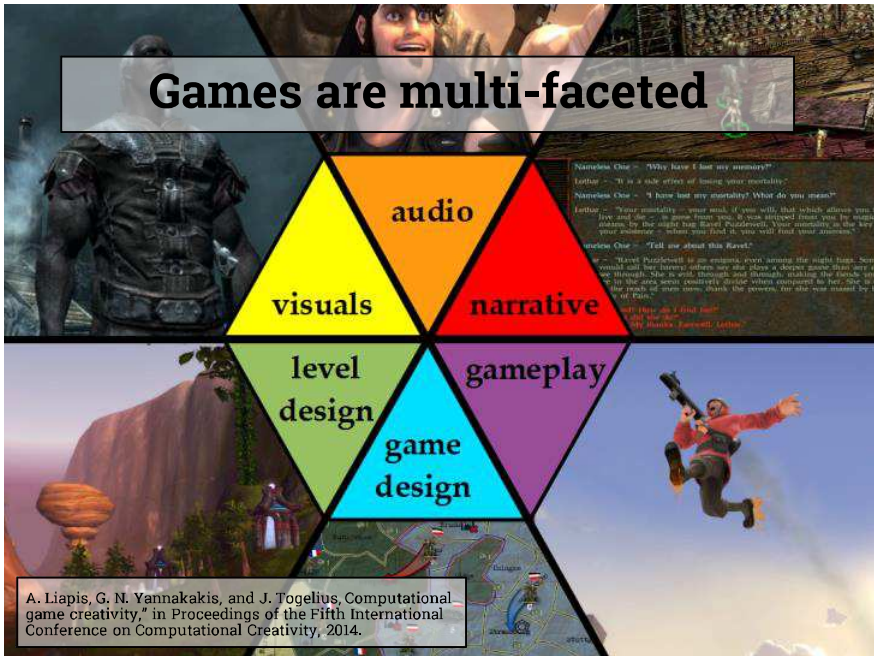
Teleportation mechanic: `HALVE player.y`



Bounce mechanic: `ADD 1 player.elasticity;`

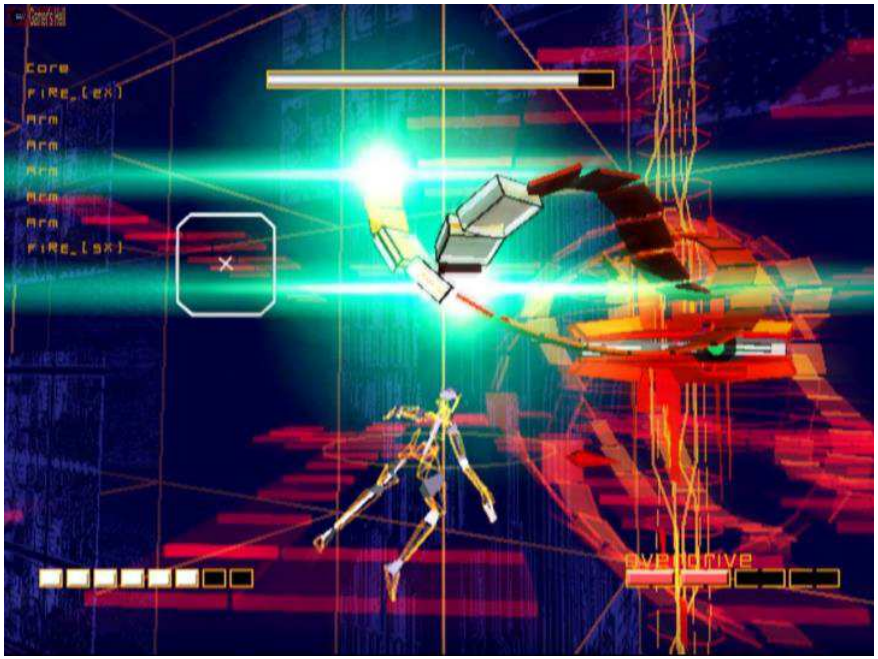
Creativity in Games

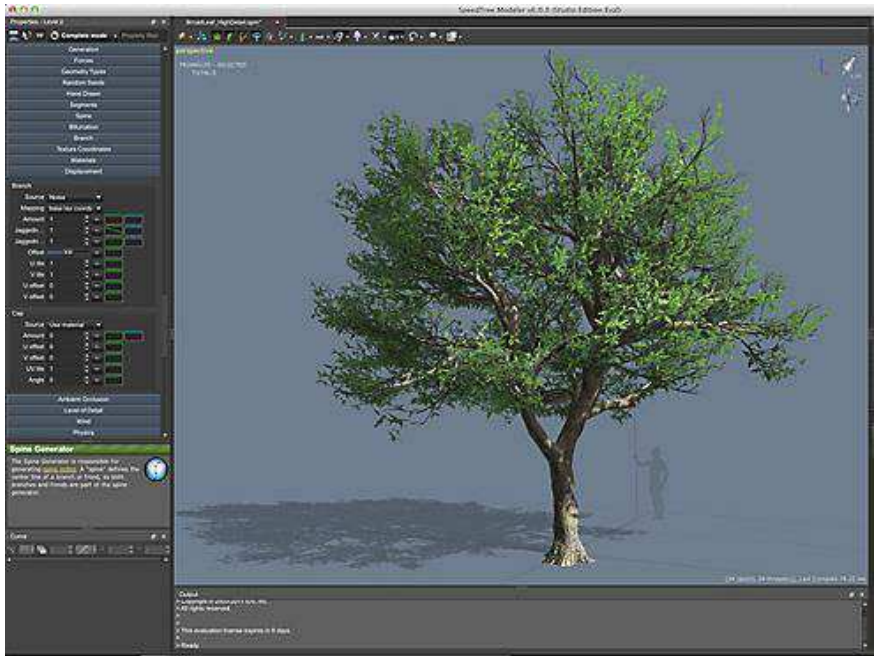
(originating from humans or computers)



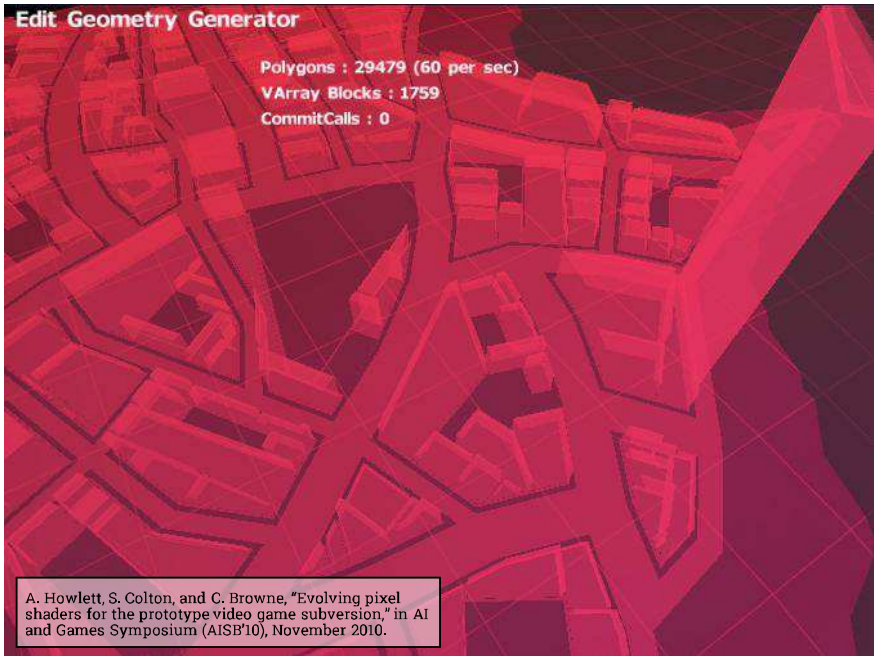
A. Liapis, G. N. Yannakakis, and J. Togelius, Computational game creativity," in Proceedings of the Fifth International Conference on Computational Creativity, 2014.


visuals


overdrive



E. J. Hastings, R. K. Guha, and K. O. Stanley, "Automatic content generation in the galactic arms race video game," IEEE Transactions on Computational Intelligence and AI in Games, vol. 1, no. 4, pp. 245–263, 2009.

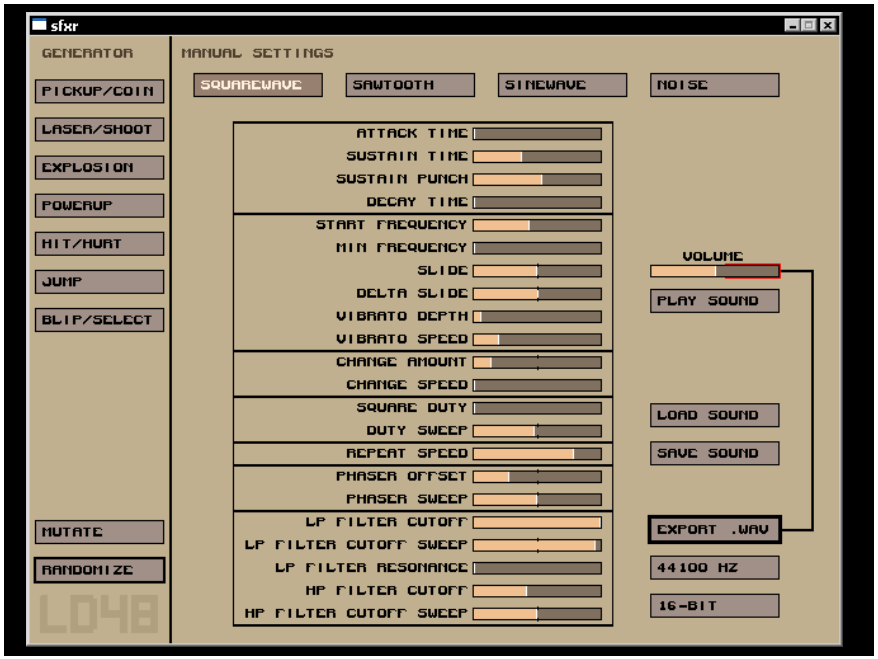


A. Howlett, S. Colton, and C. Browne, "Evolving pixel shaders for the prototype video game subversion," in AI and Games Symposium (AISB'10), November 2010.

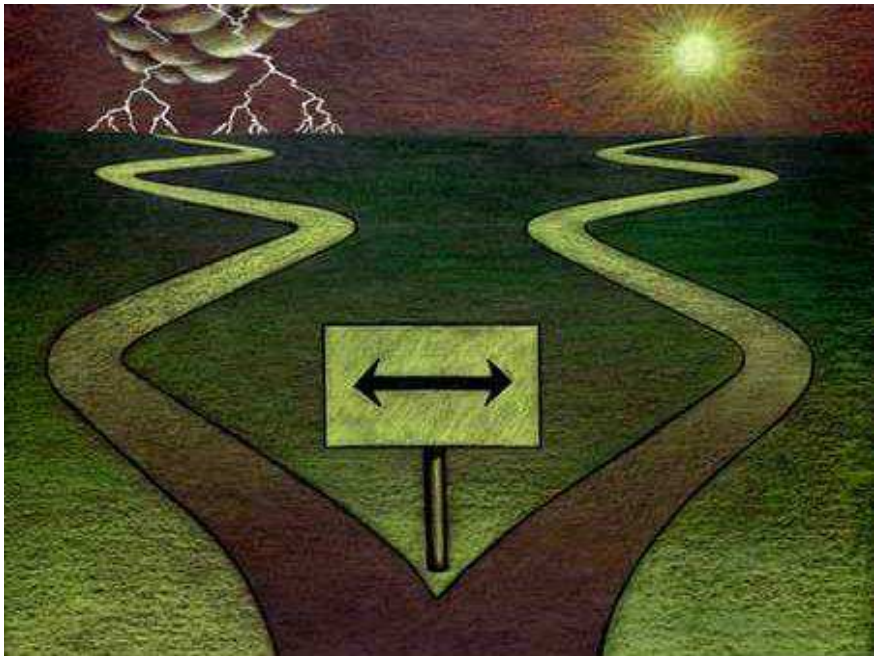
A. Liapis: "Recomposing the Pokémon Color Palette," in Applications of Evolutionary Computation. Springer, 2018.


audio


BONUS
menu
430


sfxr
GENERATOR
MANUAL SETTINGS
PICKUP/COIN
LASER/SHOOT
EXPLOSION
POWERUP
HIT/HURT
JUMP
BLIP/SELECT
MUTATE
RANDOMIZE
SQUAREWAVE
SAWTOOTH
SINEWAVE
NOISE
ATTACK TIME
SUSTAIN TIME
SUSTAIN PUNCH
DECAY TIME
START FREQUENCY
MIN FREQUENCY
SLIDE
DELTA SLIDE
VIBRATO DEPTH
VIBRATO SPEED
CHANGE AMOUNT
CHANGE SPEED
SQUARE DUTY
DUTY SWEEP
REPEAT SPEED
PHASER OFFSET
PHASER SWEEP
LP FILTER CUTOFF
LP FILTER CUTOFF SWEEP
LP FILTER RESONANCE
HP FILTER CUTOFF
HP FILTER CUTOFF SWEEP
VOLUME
PLAY SOUND
LOAD SOUND
SAVE SOUND
EXPORT .WAV
44100 HZ
16-BIT

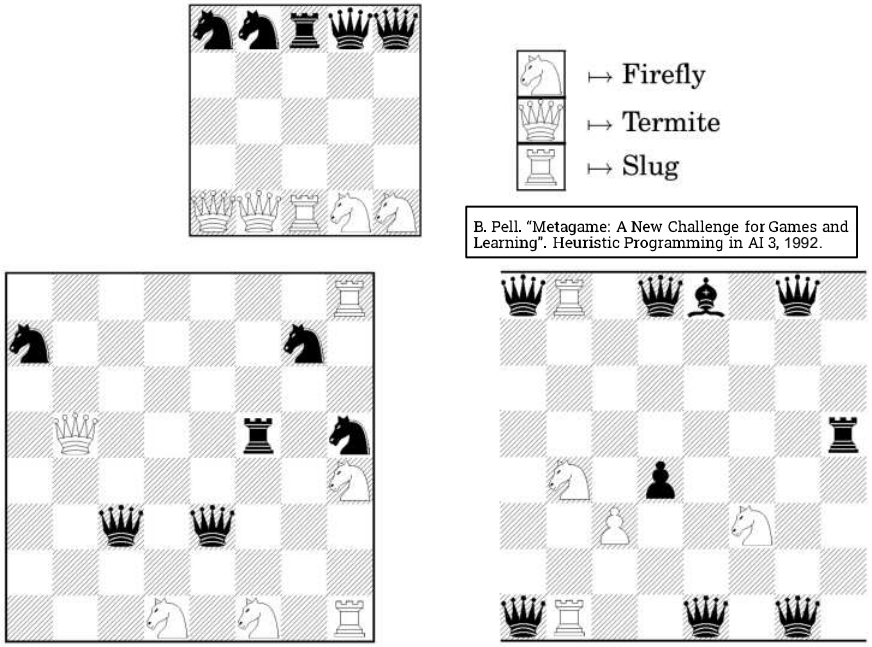

narrative
This is between Ravel and I. Look, Ravel --"
skull, skull..." Ravel clicks her tongue
widens. "Your expression is difficult to
skin wrapping, but I feel your FEAR from here.
as "not" your choice."
Morte - "Vven, I didn't have anything BETTER to do except go to one of the Lady's mazes and meet one of the evilest creatures ever to set foot in Sigil, so I said 'sure! Why n-?'
1. "Morte, be quiet. Ravel, I..."
70898




Grace, are you angry at Trip?
M. Mateas, and A. Stern. "Façade: An Experiment in Building a Fully-Realized Interactive Drama", Game Developers Conference (GDC'03), 2003.

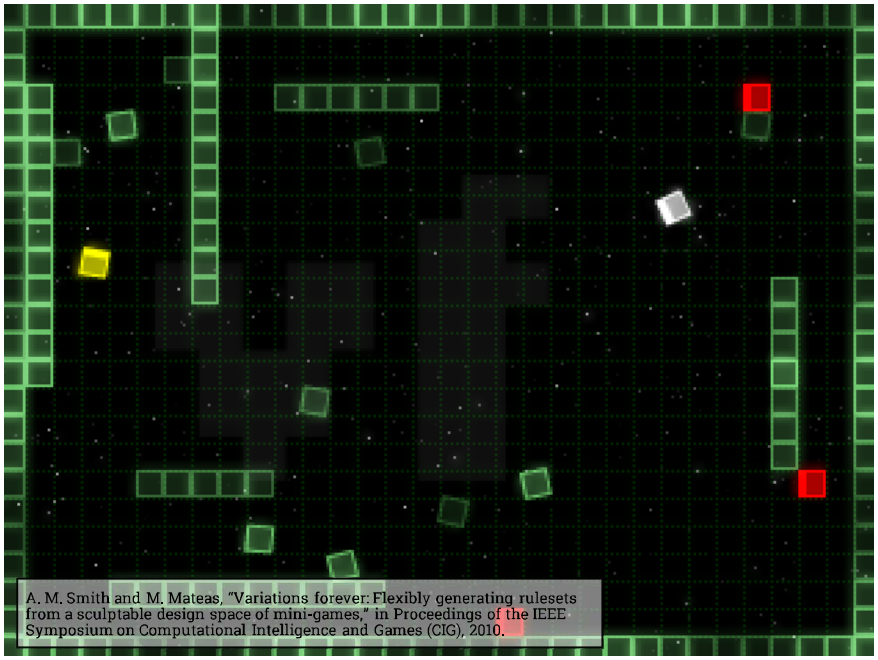
J. McCoy, M. Treanor, B. Samuel, A. A. Reed, N. Wardrip-Fruin, and M. Mateas, "Prom Week: Designing past the game/story dilemma," in Proceedings of the International Conference on the Foundations of Digital Games, 2013.

R. Hodhod and B. Magerko "Reaching Cognitive Consensus with Improvisational Agents," Proceedings, The Eighth AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment. 2012.

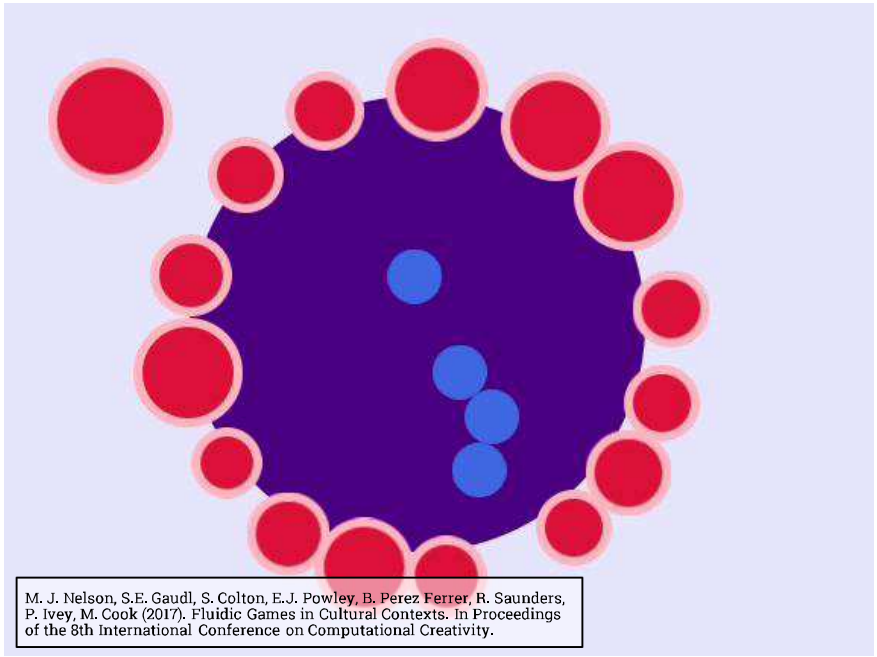


B. Pell. "Metagame: A New Challenge for Games and Learning". Heuristic Programming in AI 3, 1992.

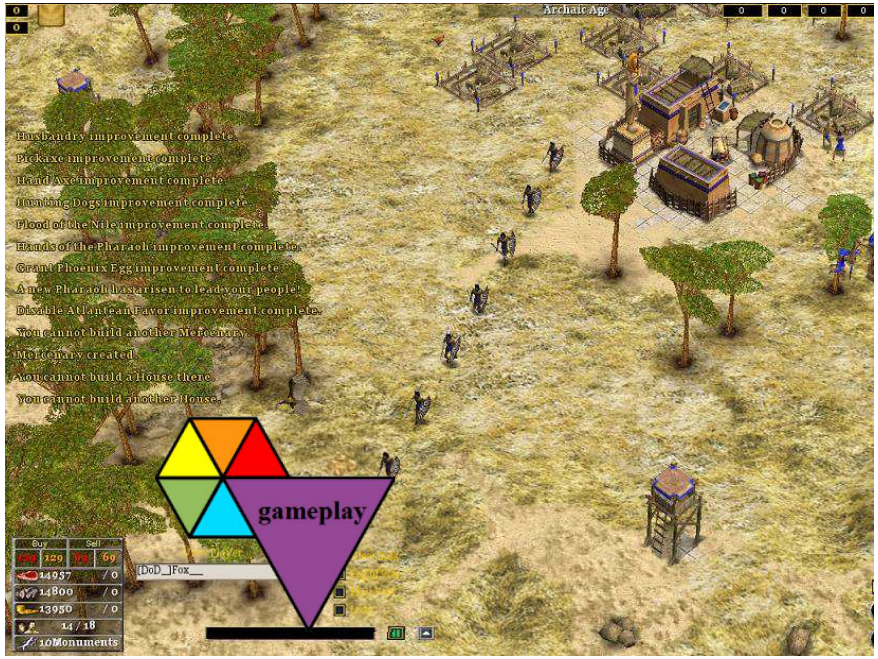
C. Browne and F. Maire, "Evolutionary game design," IEEE Transactions on Computational Intelligence and AI in Games, vol. 2, no. 1, pp. 1–16, 2010.



A. M. Smith and M. Mateas, "Variations forever: Flexibly generating rulesets from a sculptable design space of mini-games," in Proceedings of the IEEE Symposium on Computational Intelligence and Games (CIG), 2010.

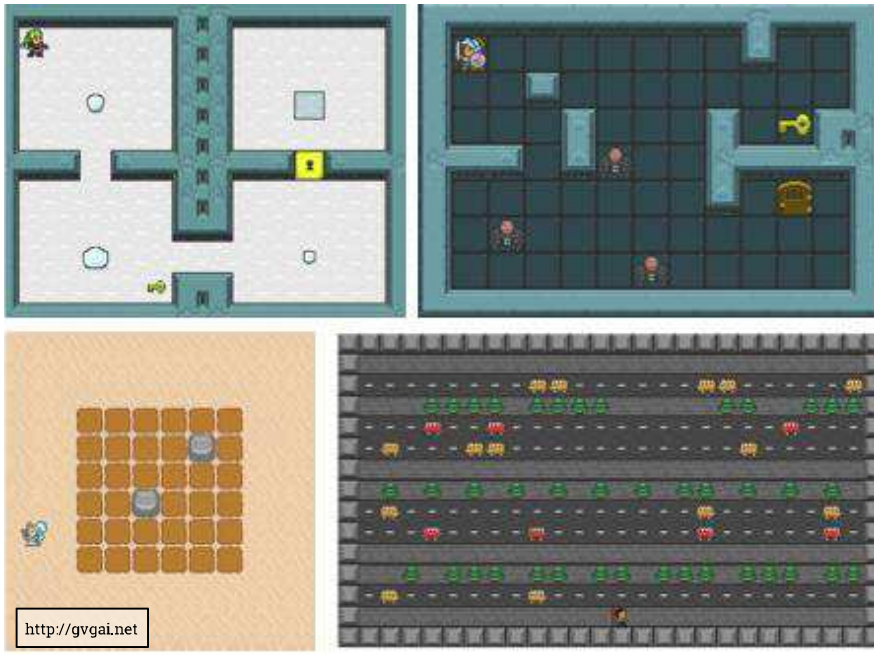


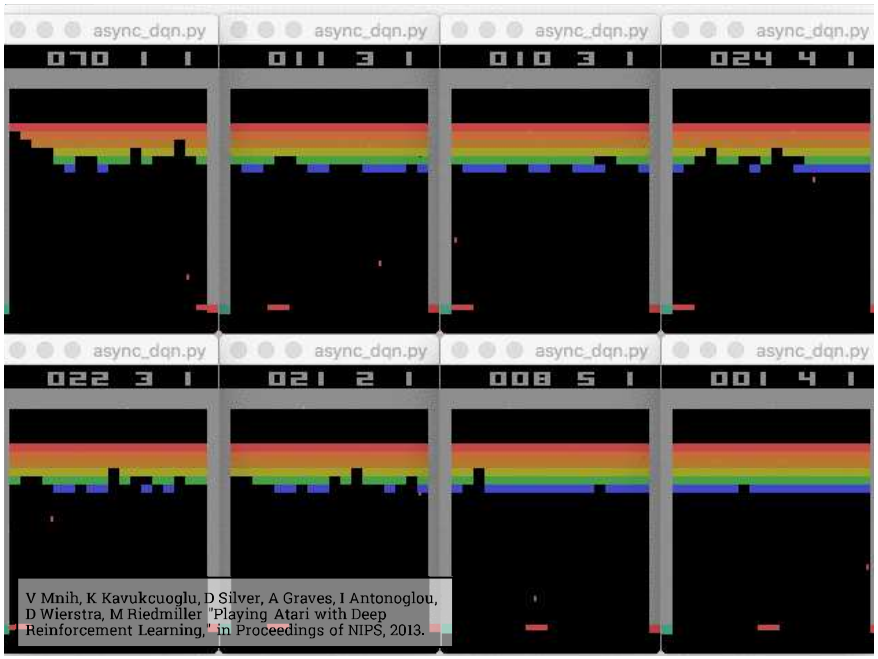
M. J. Nelson, S.E. Gaudl, S. Colton, E.J. Powley, B. Perez Ferrer, R. Saunders, P. Ivey, M. Cook (2017). Fluidic Games in Cultural Contexts. In Proceedings of the 8th International Conference on Computational Creativity.




E Take
Bucket
WEIGHT 0.5 VALUE 1


Press Esc to exit full screen mode
MARRY ME?


http://gvgai.net


async_dqn.py
070 1 1
async_dqn.py
011 3 1
async_dqn.py
010 3 1
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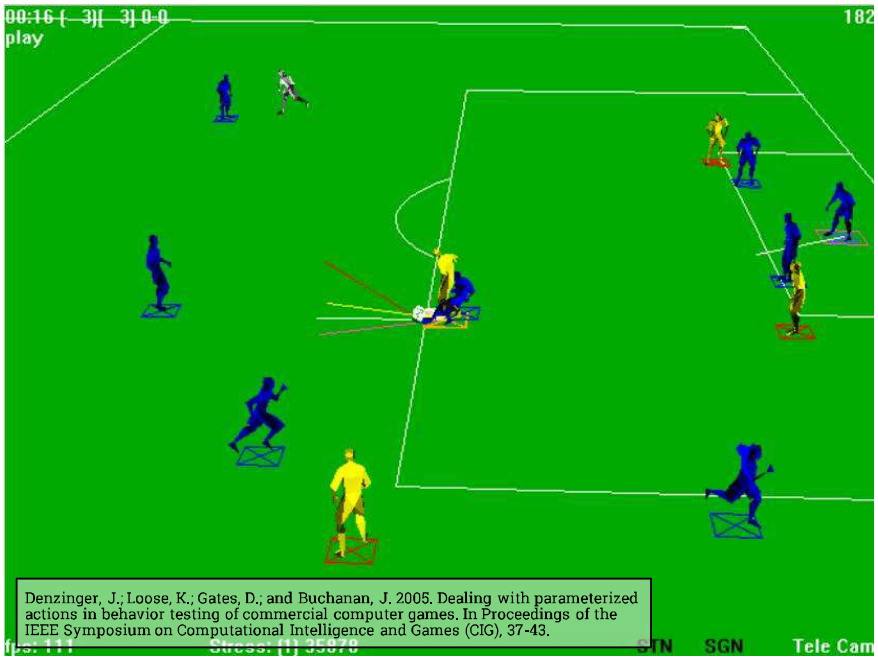
024 4 1
async_dqn.py
022 3 1
async_dqn.py
021 2 1
async_dqn.py
008 5 1
async_dqn.py
001 4 1
V Mnih, K Kavukcuoglu, D Silver, A Graves, I Antonoglou, D Wierstra, M Riedmiller "Playing Atari with Deep Reinforcement Learning," in Proceedings of NIPS, 2013.


play
Denzinger, J.; Loose, K.; Gates, D.; and Buchanan, J. 2005. Dealing with parameterized actions in behavior testing of commercial computer games. In Proceedings of the IEEE Symposium on Computational Intelligence and Games (CIG), 37-43.
SGN
Tele Cam


KASHMIR
RESTAURANT
level
design


Antonios Liapis: "**Multi-segment Evolution of Dungeon Game Levels**," In Proceedings of the Genetic and Evolutionary Computation Conference, 2017.
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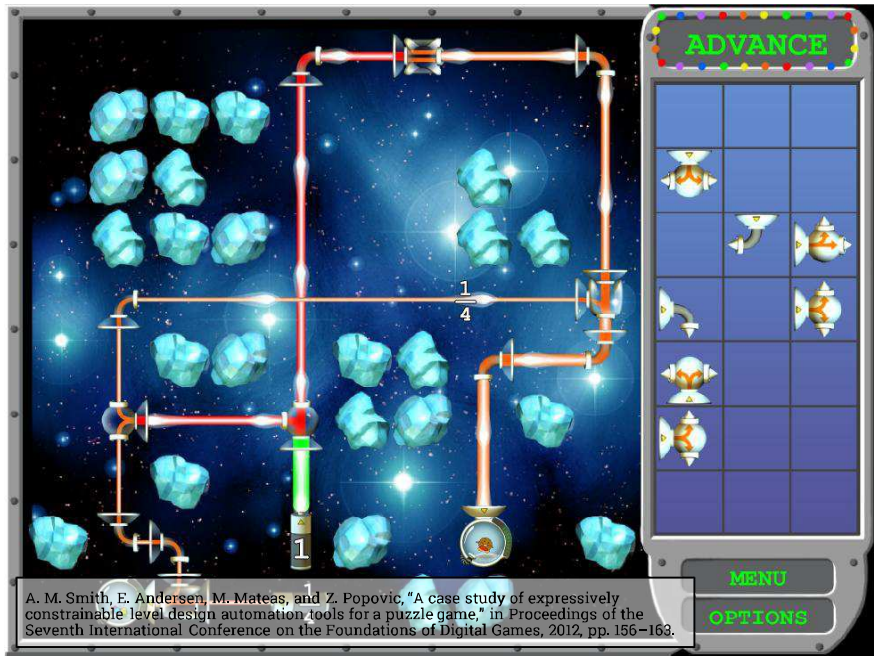

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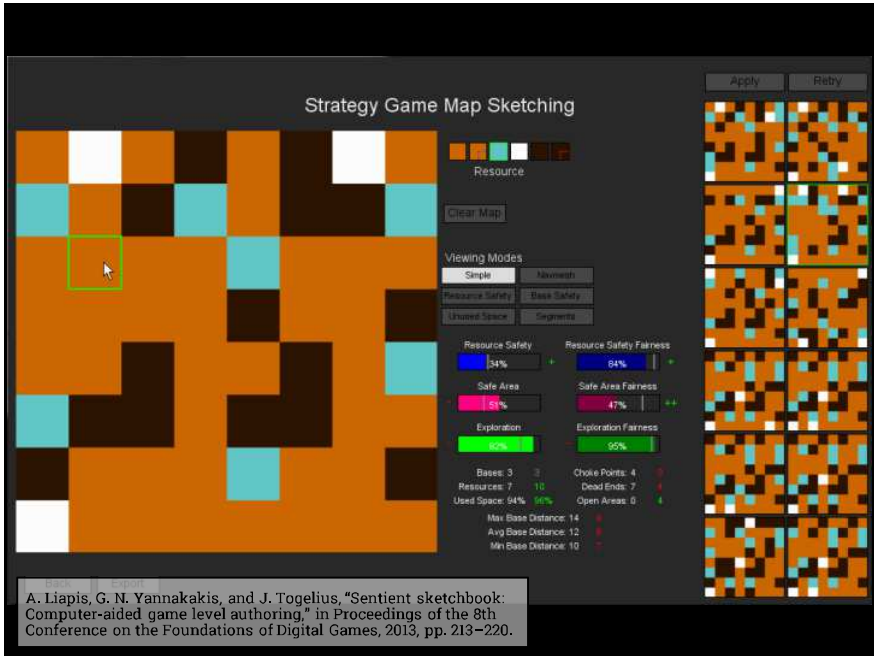

A. Liapis, G. N. Yannakakis, and J. Togelius, "Sentient sketchbook: Computer-aided game level authoring," in Proceedings of the 8th Conference on the Foundations of Digital Games, 2013, pp. 213–220.

Next Steps

Future challenges

- **Orchestrating** multiple facets: how to assess value when audio, visuals, plot, (rules? levels?) all contribute to the same artifact?
- **Deep learning** to drive novelty, surprise, and diversity? And from which **data sources**?
- **Human creativity** back in the loop: interfacing & explaining EC/ML approaches.

Antonios Liapis, Georgios N. Yannakakis, Mark J. Nelson, Mike Preuss and Rafael Bidarra: "Orchestrating Game Generation," in Transactions on Games, vol. 11, no 1, pp. 48-68, 2019.

Emotion as a driver for CC

- Mathematical models of surprise are one thing...
- Can we drive EC on computational models of surprise, joy, arousal that match human notions (e.g. from crowdsourcing?)

Thank you!

?