



Infinite Art Gallery:

A Game World of Interactively Evolved Artwork

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Introduction and Related Work

Compositional Pattern Producing Networks (CPPNs [1]) are a type of neural network that has been used to create many types of artistic and creative output. The Infinite Art Gallery is a project that uses CPPNs to create various forms of novel art and present them to a player in the form of a game. The evolutionary algorithm NEAT (NeuroEvolution of Augmenting Topologies [2]) was incorporated into the Unity game development environment. NEAT was then used to produce different types of artwork that are presented to the player in a procedurally generated gallery and are continuously evolved based on the player's choices.

The Infinite Art Gallery incorporates several previous approaches used in the generation of evolved art, including Picbreeder and Endless Forms. Picbreeder [1] showed that artistic two-dimensional images could be produced by evolved CPPNs. Endless Forms [3] expanded upon Picbreeder to add a third dimension to the inputs and a new output that determined if a single unit coordinate in a three-dimensional space (voxel) was present in the produced form.

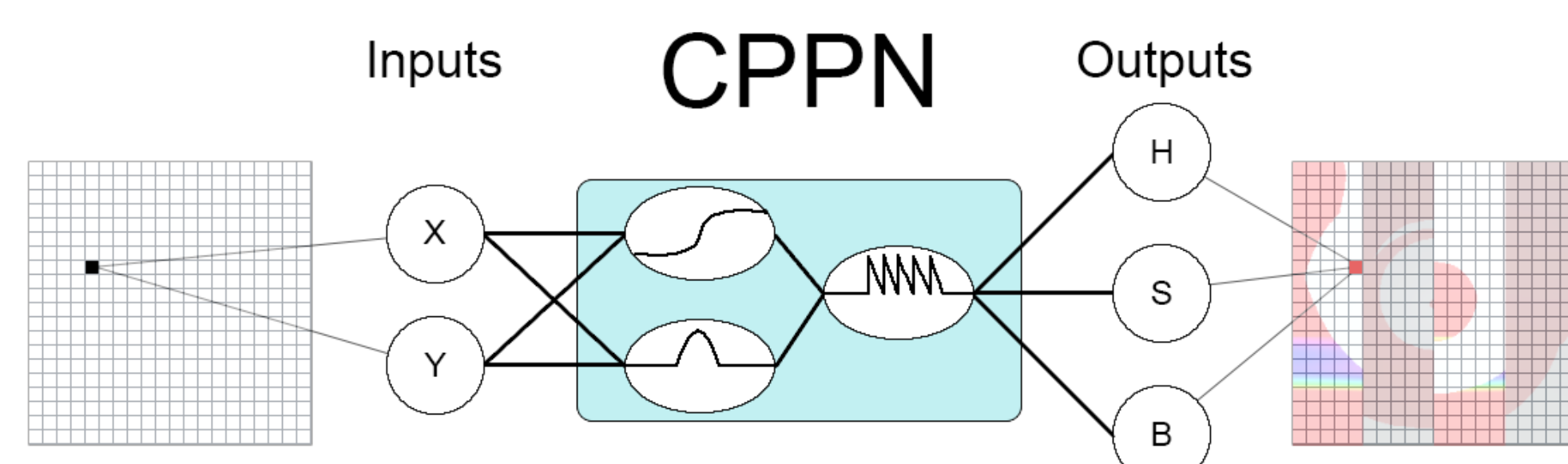


Fig. 1 - Signal processing through an example CPPN for a two dimensional image. Each input coordinate results in the Hue, Saturation, and Brightness of the pixel in the output image.

Game Features

- Two and three dimensional artwork to explore
- Item pickups to modify CPPNs, influencing the final artwork
- Artwork inventory saves specific CPPNs for later use
- Reversing travel through the gallery rewinds selections, allowing for alternate paths to be explored

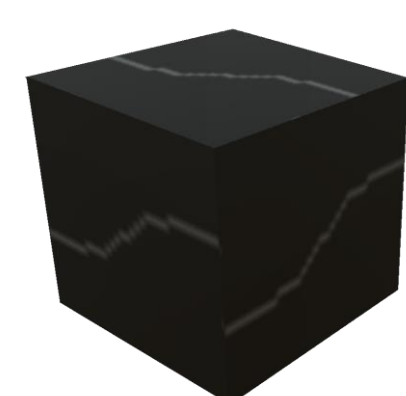


Fig 2 - TanH function item pickup in game.

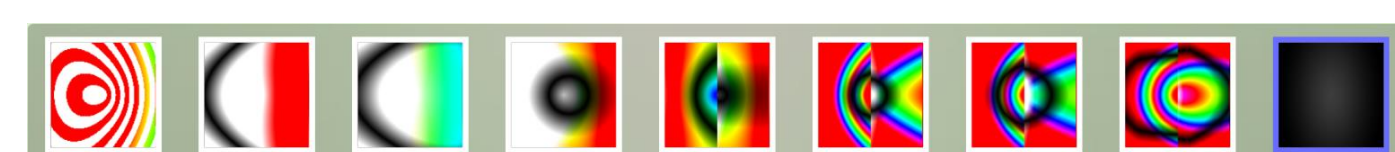


Fig. 3 - Saved artwork inventory bar with examples of each evolution in a series.

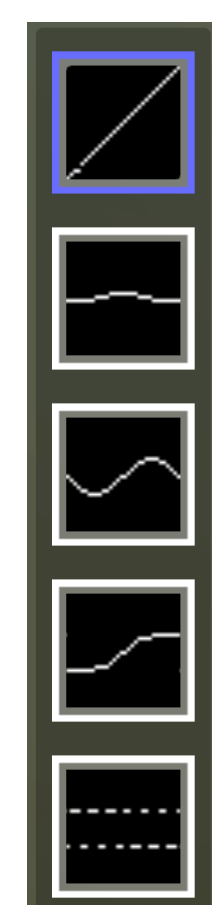


Fig 4 - Activation function inventory bar with 5 functions active.

Infinite Art Gallery

The Infinite Art Gallery uses neural networks to create two-dimensional and three-dimensional artifacts and present them to the player. The player selects works that are interesting to them and continues to explore the gallery. As the player explores, the gallery evolves the CPPNs that created the selected works and presents new creations.

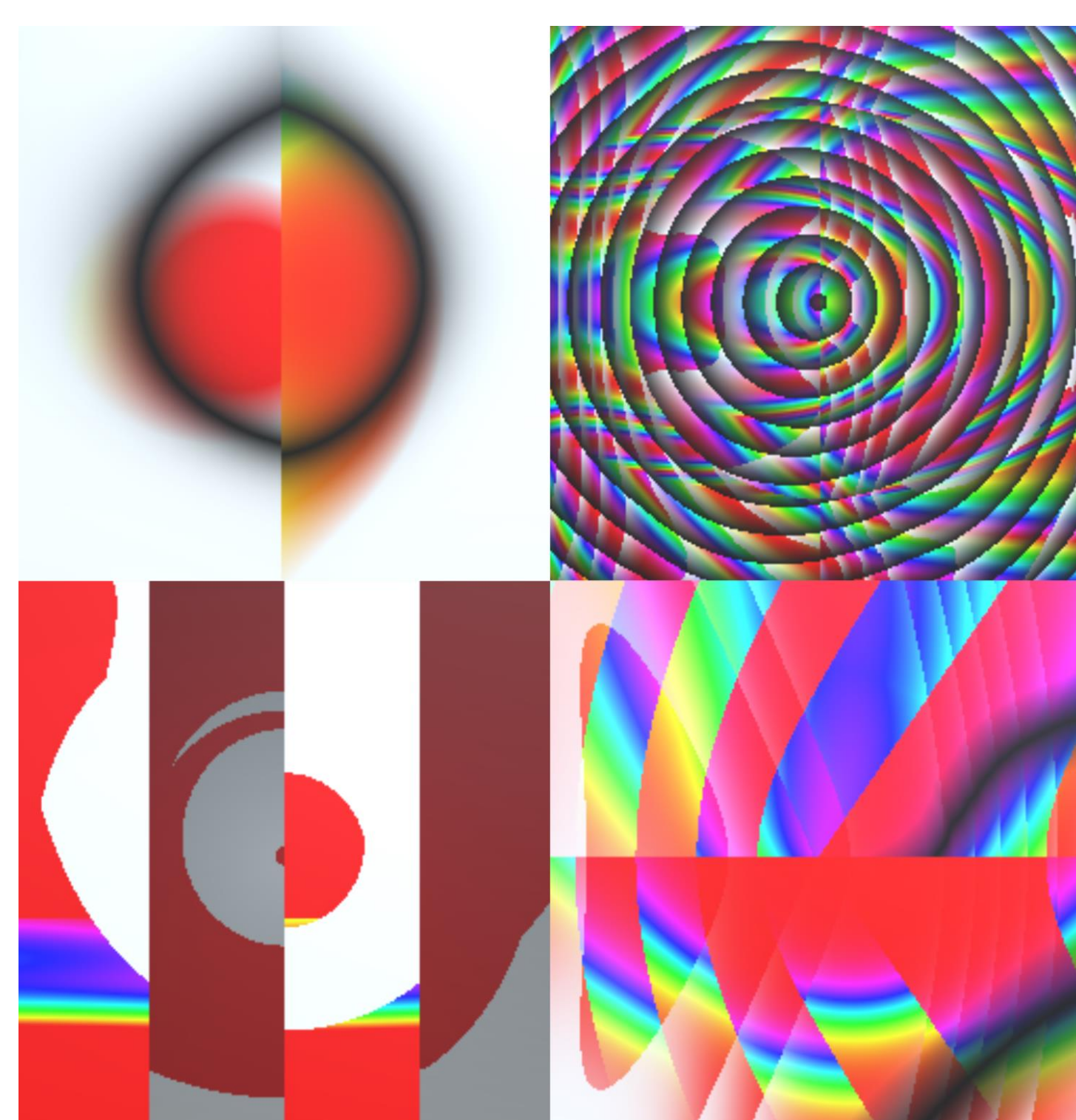


Fig. 5 - Two-dimensional artwork generated by CPPNs

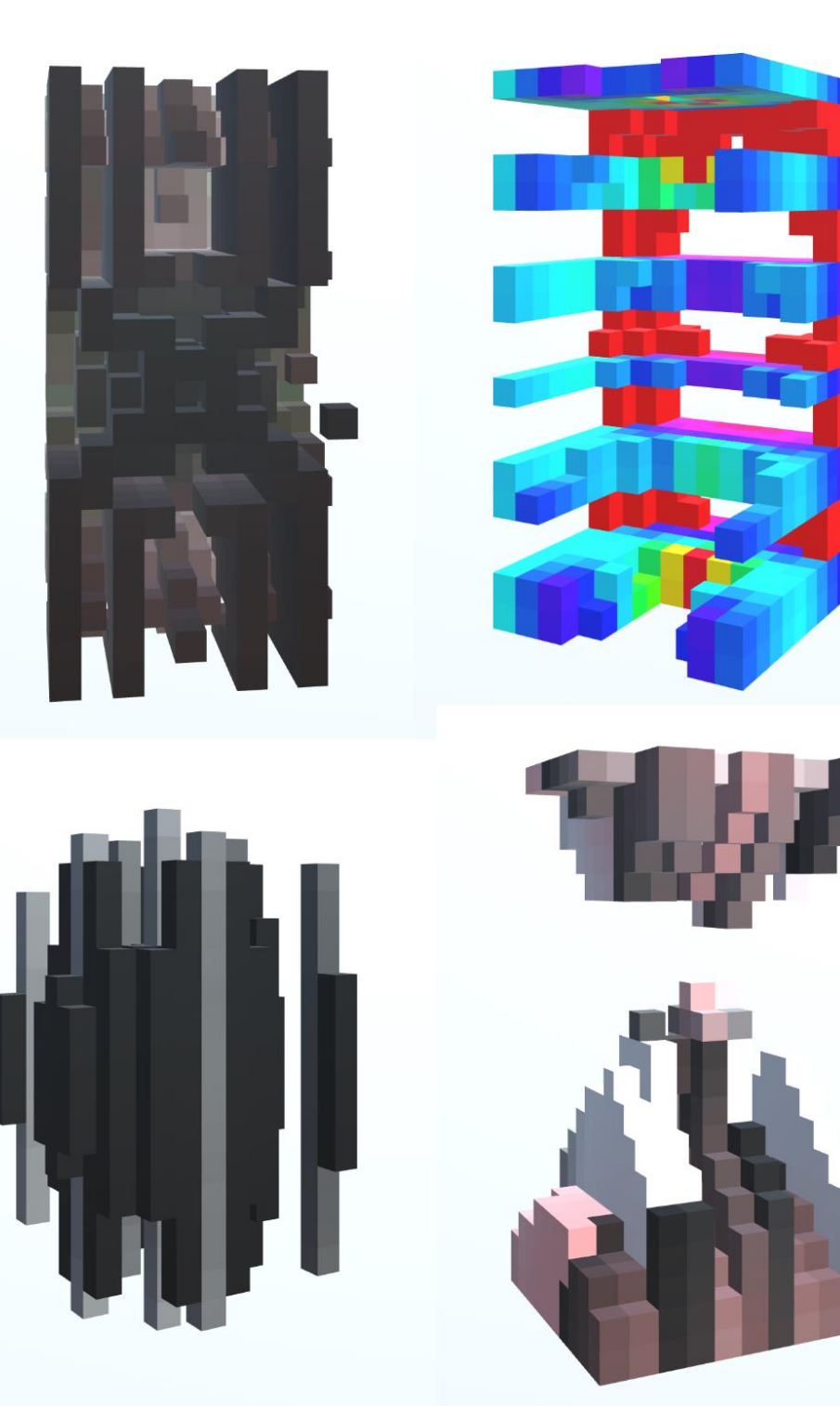


Fig. 6 - Three-dimensional sculptures generated by CPPNs

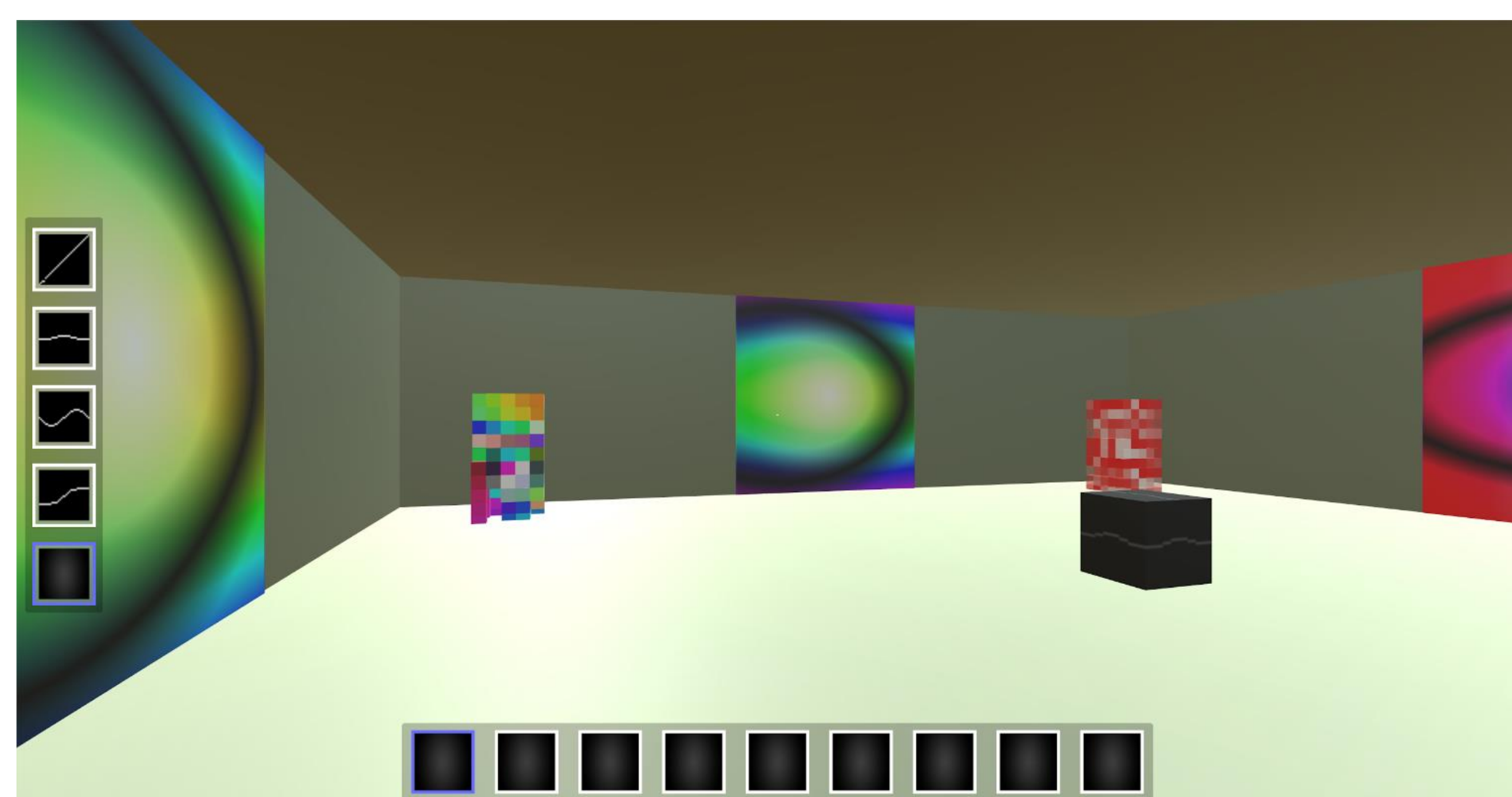


Fig. 7 - Full gallery interface screenshot showing activation function inventory on the left side, saved artwork inventory on the bottom, generated two-dimensional artwork on the three walls, two three-dimensional sculptures in the corners, and an activation pickup in the center of the room.

Human Study

To gauge user response to the game, a human subject study was conducted with 30 users. Average overall enjoyment was 4.2 on a 5 point scale, indicating a general appreciation of the game.

User Enjoyment And Desire to Play More

Rating	1	2	3	4	5
Game	0%(0)	0%(0)	16.6%(5)	46.6%(14)	36.6%(11)
2D Art	0%(0)	0%(0)	13.3%(4)	33.3%(10)	53.3%(16)
3D Art	3.3%(1)	23.3%(7)	33.3%(10)	26.6%(8)	13.3%(4)
Desire	3.3%(1)	6.6%(2)	20%(6)	33.3%(10)	36.6%(11)

Ratings of Individual Game Components

Rating	1	2	3	4	5
2D Variation	0%(0)	10%(3)	16.6%(5)	50%(15)	23.3%(7)
2D Choice	0%(0)	3.3%(1)	6.6%(2)	40%(12)	50%(15)
2D Items	10%(3)	20%(6)	30%(9)	26.6%(8)	13.3%(4)
2D Inventory	3.3%(1)	3.3%(1)	20%(6)	16.6%(5)	56.6%(17)
3D Variation	0%(0)	34.5%(10)	31.0%(9)	20.7%(6)	13.8%(4)
3D Choice	6.6%(2)	33.3%(10)	23.3%(7)	20%(6)	16.6%(5)
3D Items	43.3%(13)	20%(6)	30%(9)	6.6%(2)	0%(0)

Users tended to enjoy the 2D artwork over the 3D sculptures. Among the more frequent comments, users indicated that they found the environment relaxing and the exploration rewarding, with a desire to play more.

Future Work

- Crossover on 2D artwork using items in inventory as mates
- Marching cubes on sculptures (smoothing of shapes)
- New items to remove or replace functions from existing networks
- Evolving background music

References

[1] Jimmy Secretan, Nicholas Beato, David B. D'Ambrosio, Adelein Rodriguez, Adam Campbell, Jeremiah T. Folsom-Kovarik and Kenneth O. Stanley. Picbreeder: A Case Study in Collaborative Evolutionary Exploration of Design Space. *Evolutionary Computation* 19:3 (2011), 373-403.

[2] Kenneth O. Stanley and Risto Miikkulainen. Evolving Neural Networks through Augmenting Topologies. *Evolutionary Computation* 10:2 (2002), 99-127.

[3] Jeff Clune and Hod Lipson. Evolving 3D objects with a generative encoding inspired by developmental biology. *European Conference on Artificial Life* (2011), 144-148.