Towards Game Design via Creative Machine Learning (GDCML)

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Outline

- Motivation
- Creative ML for Visual Art and Music
- Why Creative ML for Games (or GDCML)?
- Applications and Proposed System
- Future Work

Motivation

- Recent advances in machine learning have enabled ML applications for creative tasks

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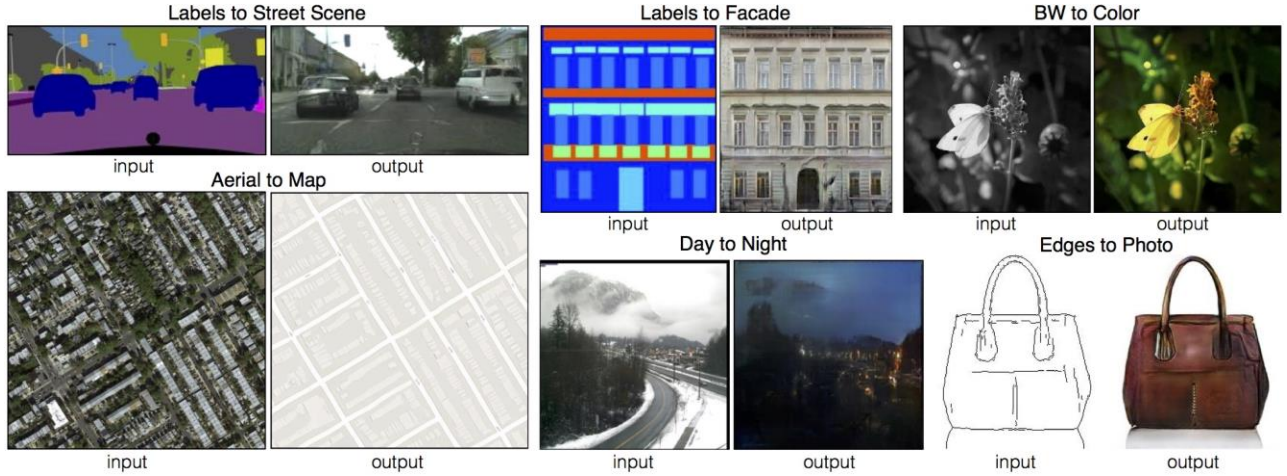
- Visual Art
  - Style transfer
  - Texture synthesis
  - Image translation

Gatys et al., 2015



Isola et al., 2017

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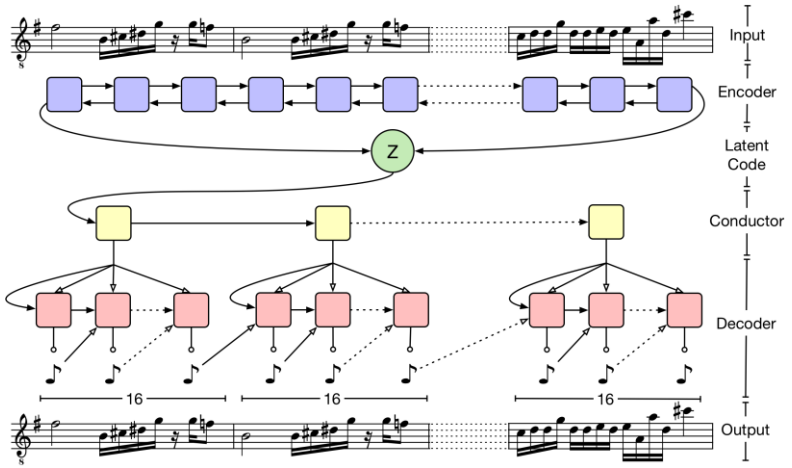
- Music
  - Generation
  - Blending of styles and genres



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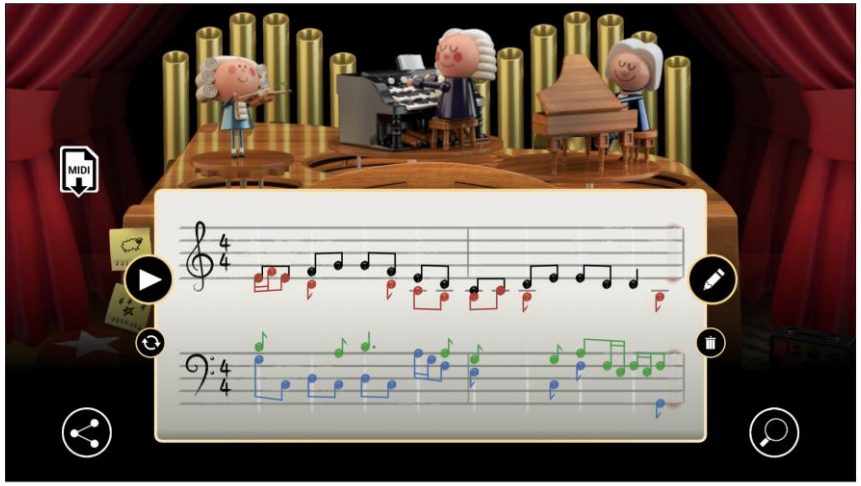

Coconet, Huang et al., 2019

Motivation

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- Visual Art
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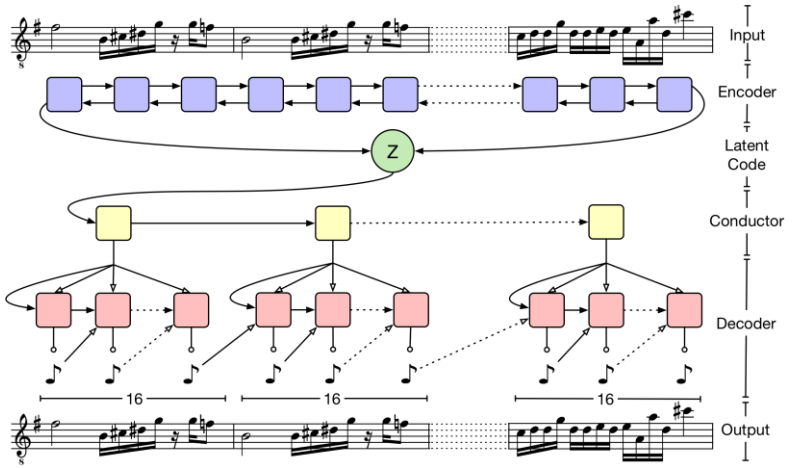
- However such ML-based creative approaches haven't been widely adopted for game design



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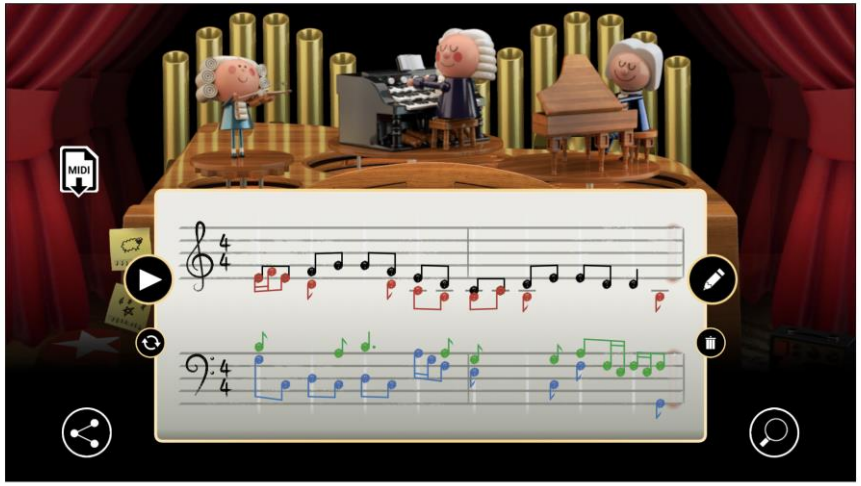

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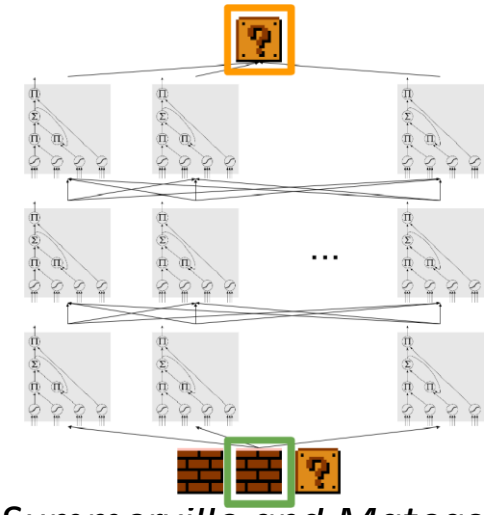
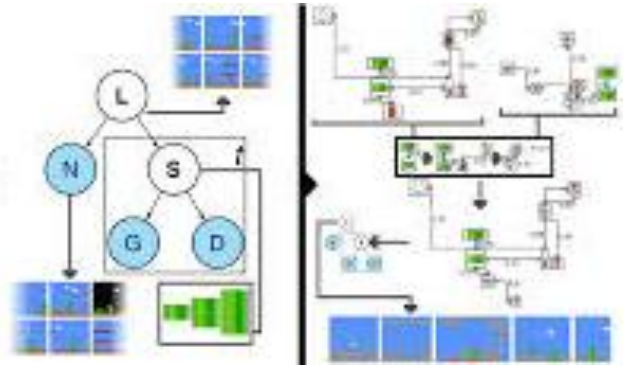
Motivation

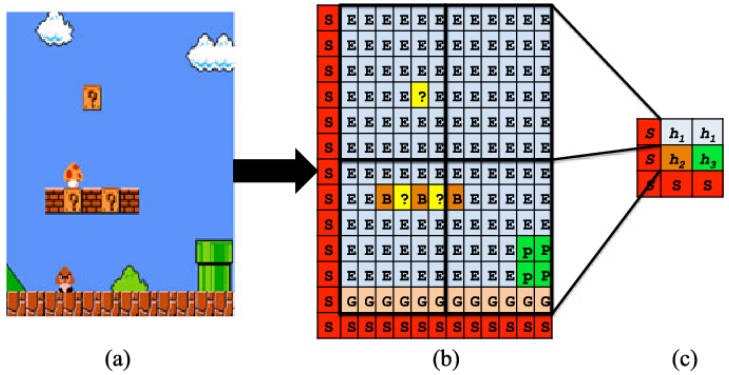
- PCGML methods have demonstrated feasibility of ML for generating game content



Summerville and Mateas, 2016



Guzdial and Riedl, 2016



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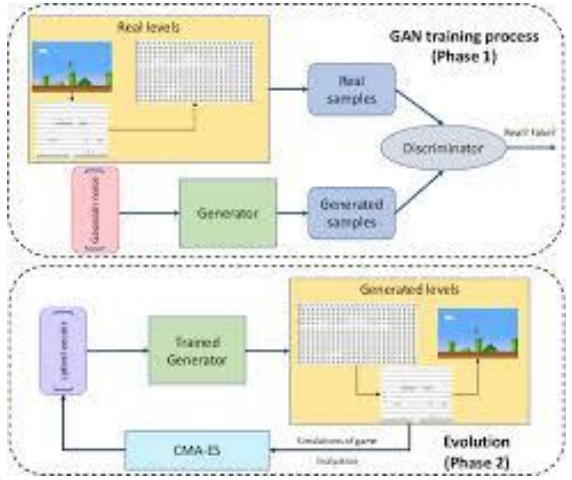
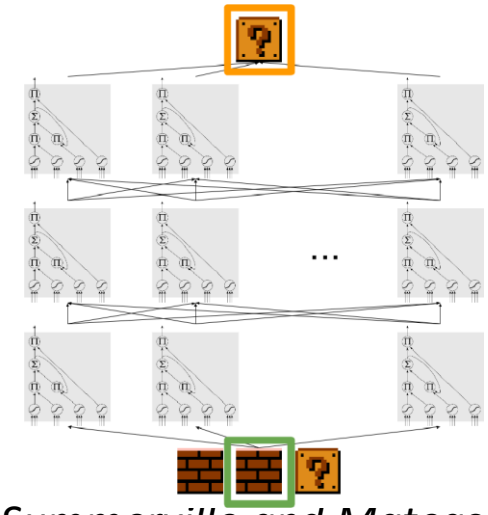


Volz et al., 2017

Motivation

- PCGML methods have demonstrated feasibility of ML for generating game content
- Focused on one game/genre; not comparable to more creative ML-based applications in visual art and music



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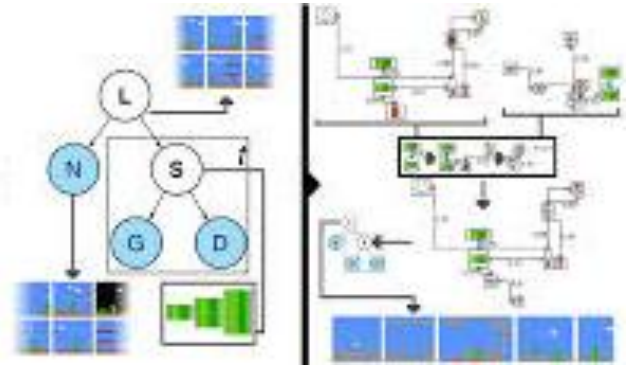

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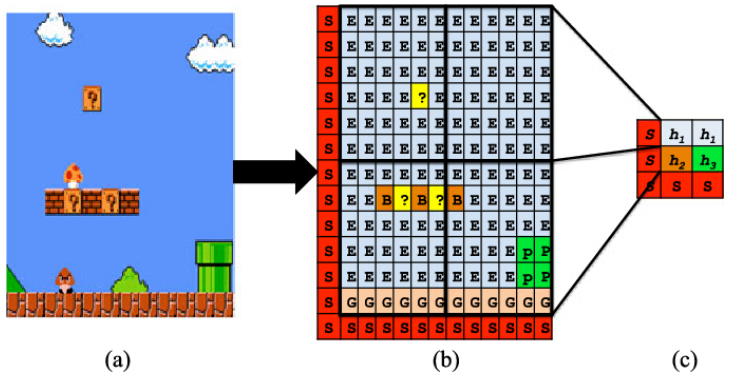

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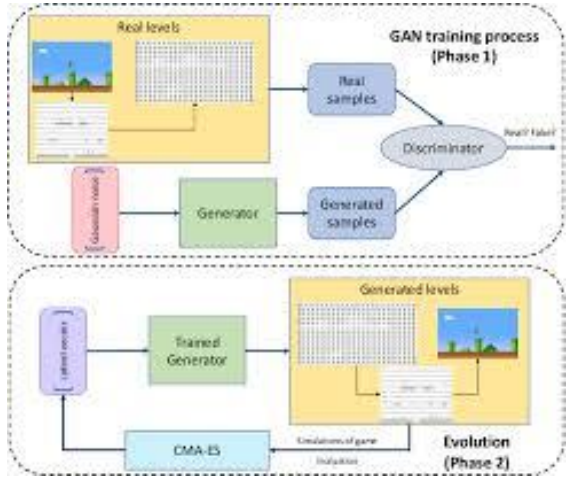

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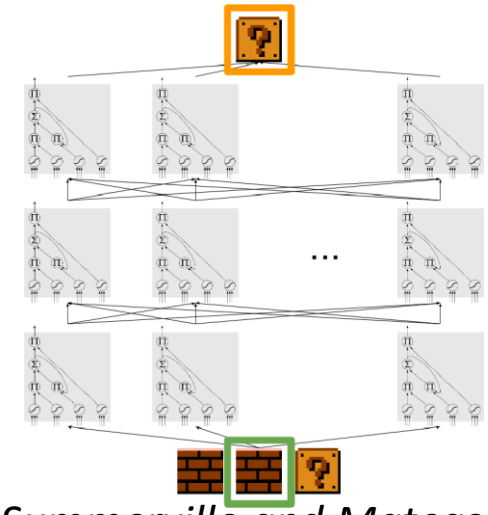
Motivation

- PCGML methods have demonstrated feasibility of ML for generating game content

- Focused on one game/genre; not comparable to more creative ML-based applications in visual art and music

- Moving towards more creative form of PCGML
  - Applications such as domain transfer, blending and game generation
  - ML-powered co-creative game design tools



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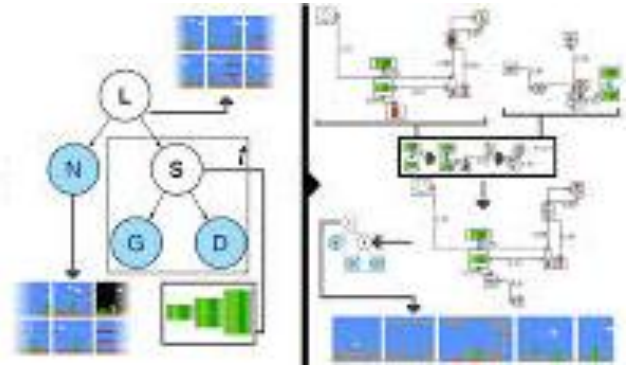

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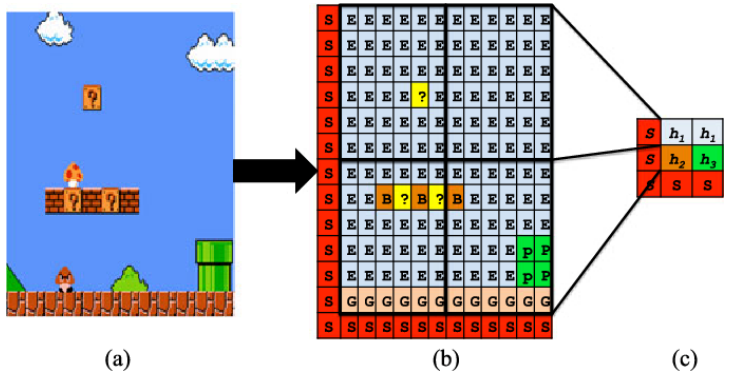

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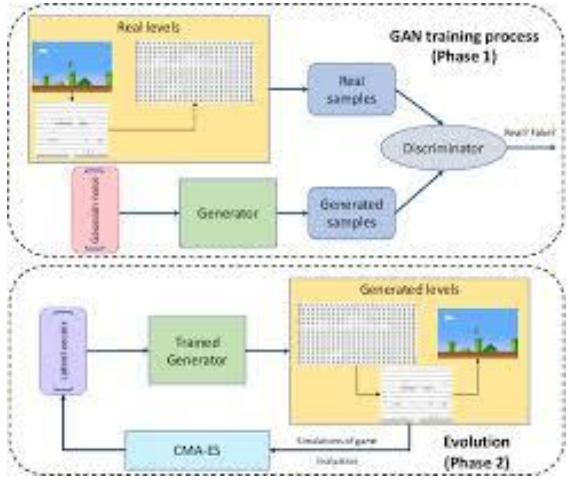

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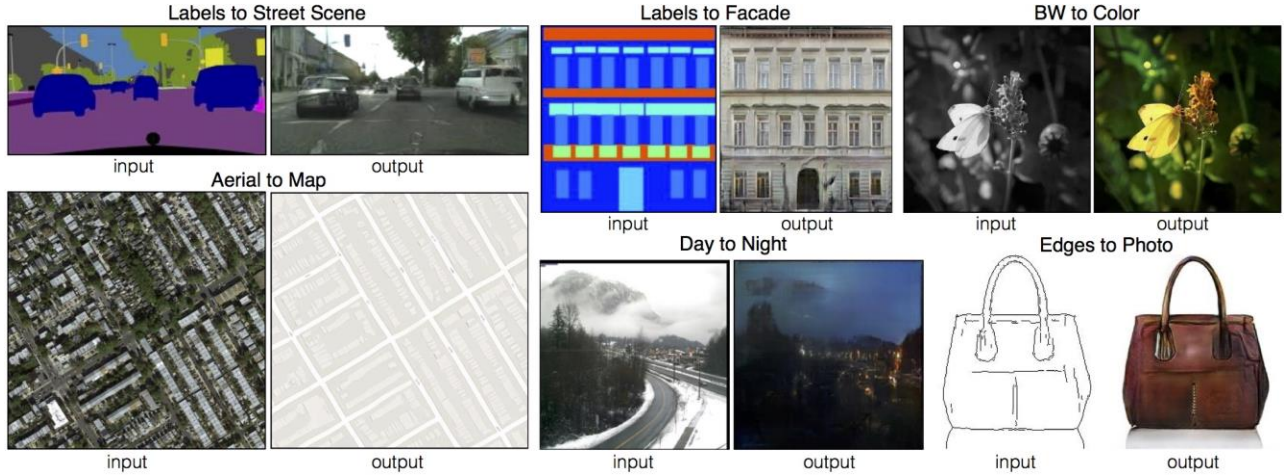
Game Design via Creative Machine Learning (GDCML)

A subset of PCGML techniques that use models trained on one or more games to enable creative ML applications/affordances for automated and mixed-initiative game-design tools

Creative ML for Visual Art

- Creative applications of ML for visual art
  - Image style transfer/texture synthesis
  - Image transformation using pix2pix and CycleGAN

Neural Style Transfer, Gatys et al., 2015



pix2pix, Isola et al., 2017

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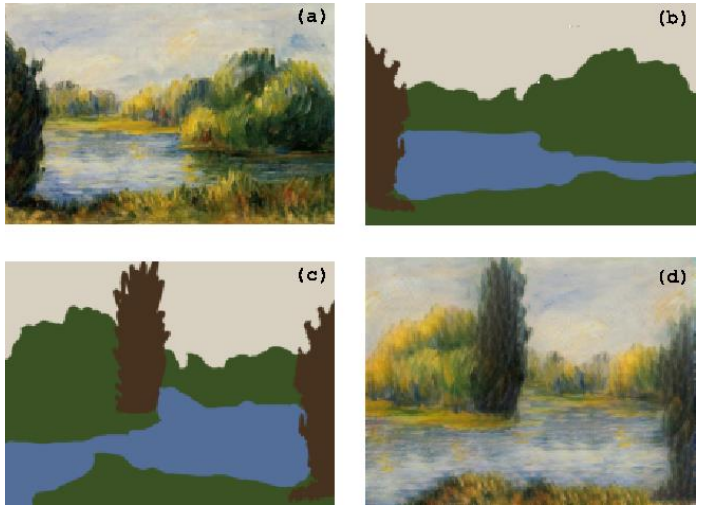
- Interactive tools and applications
  - Neural Doodle
  - GAN Paint



Neural Doodle, Champandard, 2016

GANPaint, Bau et al., 2018

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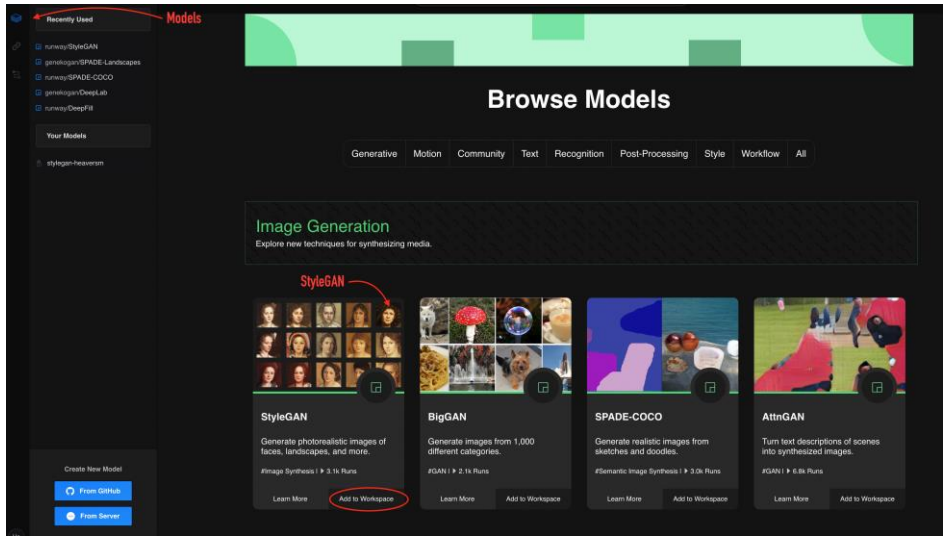
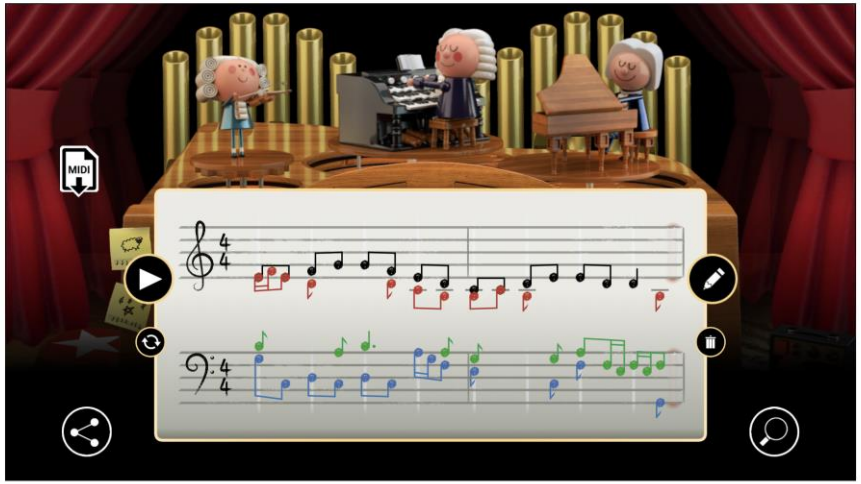
- Software suites like RunwayML that let users work on artistic tasks using pretrained models



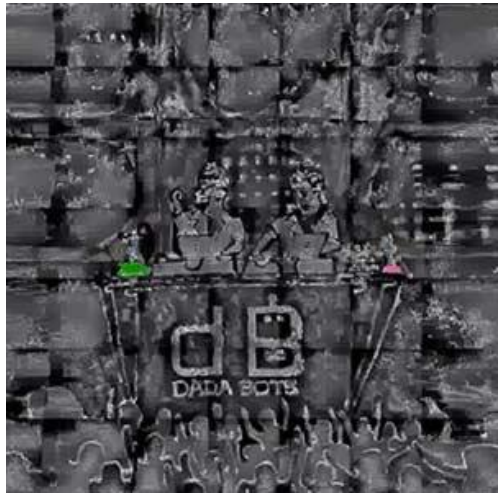
RunwayML, source: heartbeat.fritz.ai

Creative ML for Music

- Generative models of music using different representations and for different genres



Coconet, Huang et al., 2019
Source: magenta.tensorflow.org/coconet

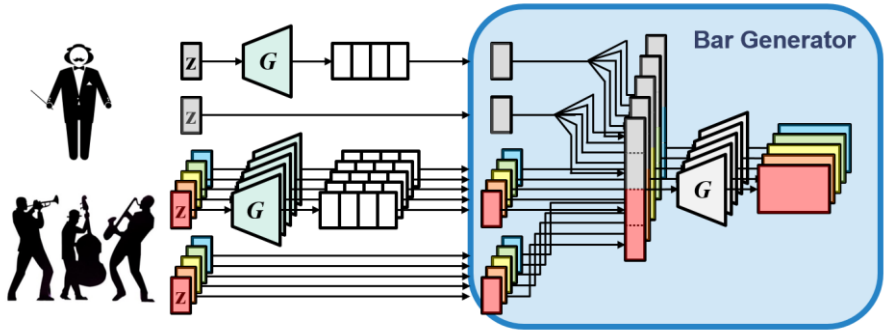


Relentless Doppelganger, Source: dadabots.com

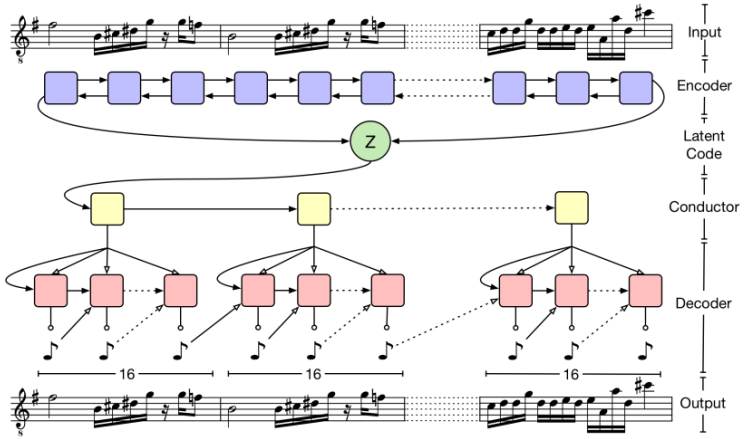
Creative ML for Music

- Generative models of music using different representations and for different genres

- Use of latent models like GANs and VAEs
  - learning/blending/transferring styles
  - instrument modeling
  - conditioning generation on attributes



MuseGAN, Dong et al., 2018



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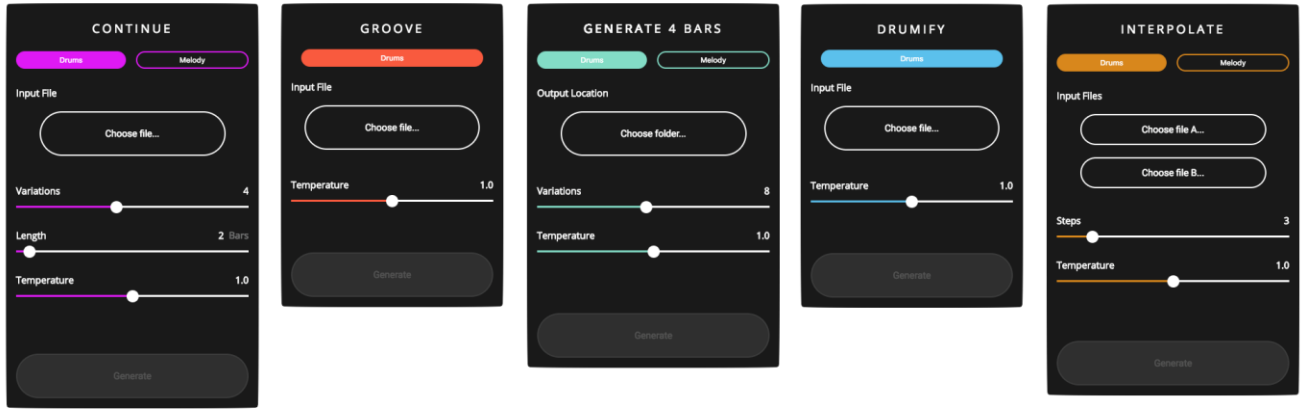
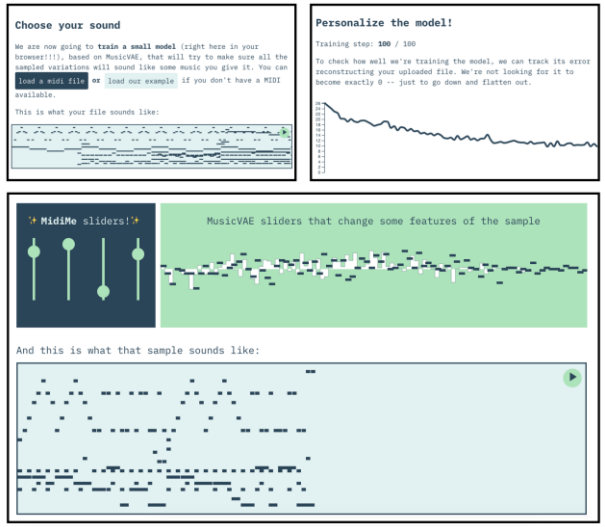
- Co-creative design tools such as Magenta Studio and MidiMe



Magenta Studio, Roberts et al., 2019



MidiMe, Dinculescu et al., 2019

Creative ML for Games?

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- We define GDCML with a view to highlight and discuss existing and future methods to enable creative ML for games

Creative AI and Creative ML

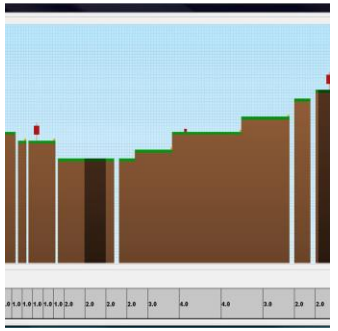
- We distinguish between *Creative AI* and *Creative ML*

- In most uses of the term ‘creative AI’ for art and music, underlying method more specifically uses ML

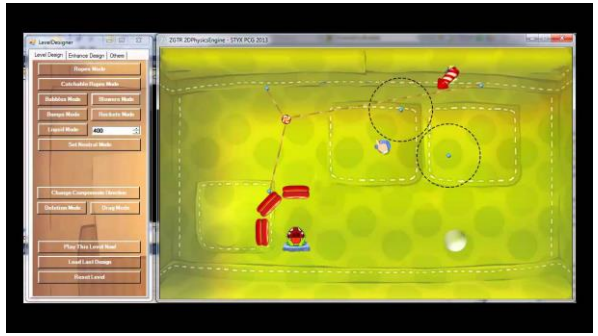
- To focus our scope, we concentrate on co-creative game design methods and tools that use ML, separate from the various tools that use general AI techniques

Creative AI in Game Design

- Co-creative game design systems
  - Tanagra (platformers)
  - Ropossum (Cut-the-Rope)
  - Sentient Sketchbook (strategy)
  - Cicero (GVG-AI)
  - Evolutionary Dungeon Designer
  - Baba is Y'All (Baba is You)

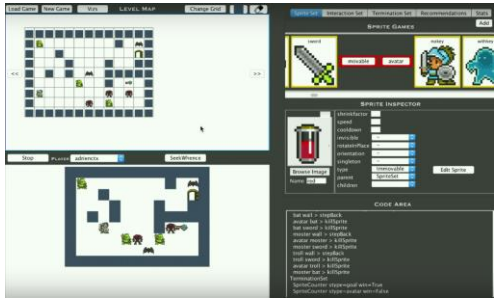


Tanagra



Ropossum

Sentient Sketchbook



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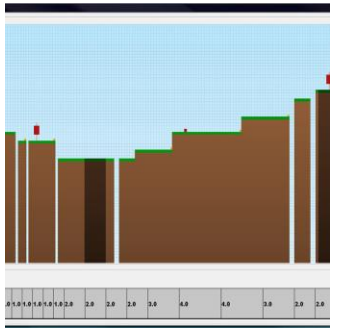
- Enable design/generation of new levels and games, but are not informed by ML models
  - Can't harness affordances that for e.g. a GAN or VAE can offer



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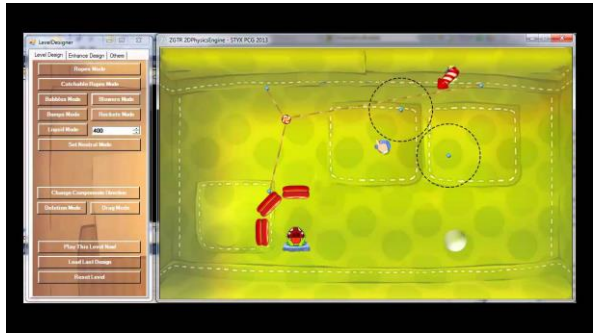

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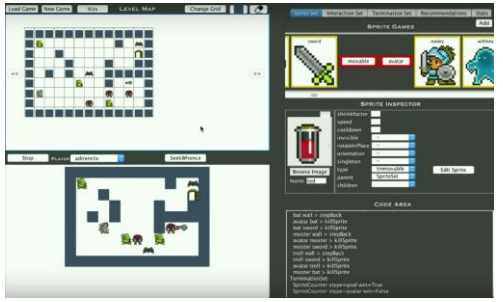

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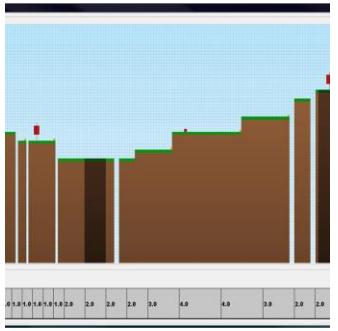
- Interested in existing and potential approaches that could leverage PCGML methods to produce GDCML tools



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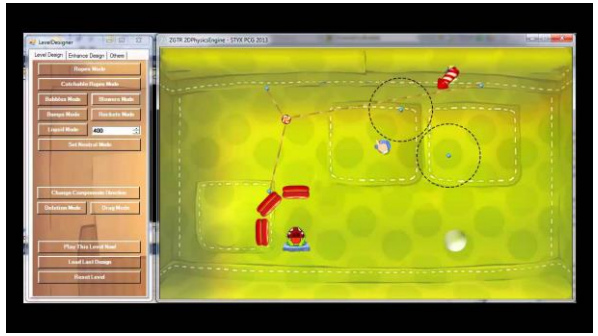

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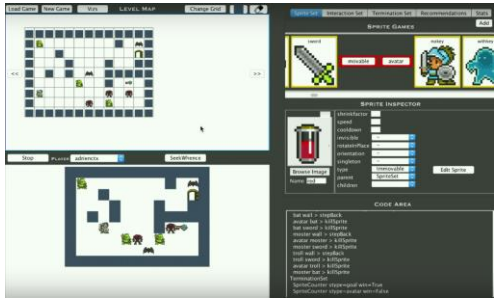

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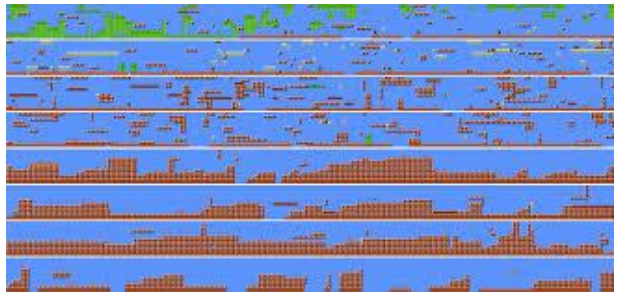
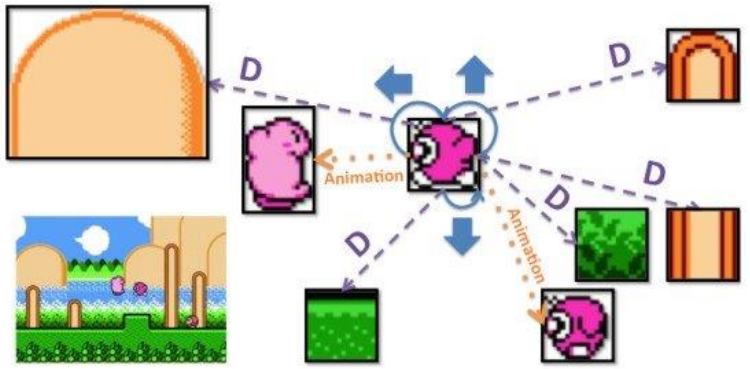
- Recent trend of more creative PCGML works
  - Domain transfer
  - Game/level blending
  - Automated game generation



Snodgrass and Ontanon, 2016

Sarkar and Cooper, 2020



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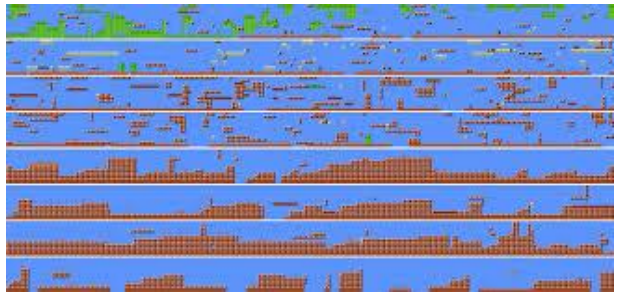

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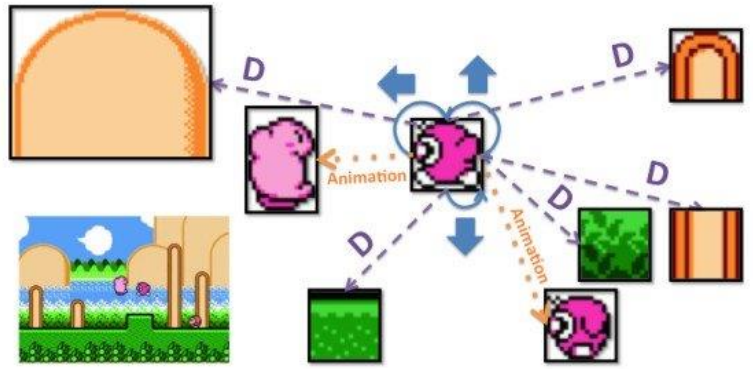

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  - Game/level blending
  - Automated game generation
- Computational creativity + PCGML models
- Combinational creativity
  - Branch of creativity focused on generating new concepts/domains/artifacts by combining existing ones

"the idea [is] that creativity is combinatorial, that nothing is entirely original, that everything builds on what came before, and that we create by taking existing pieces of inspiration, knowledge, skill and insight that we gather over the course of our lives and recombining them into incredible new creations"

- Maria Popova

Why GDCML?

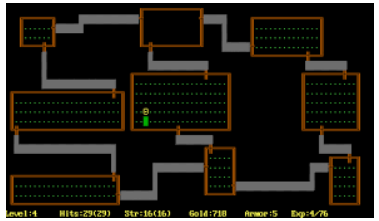
- Combinational creativity evident throughout history of games

Super Mario Bros.

The Legend of Zelda

Super Metroid

Super Mario Bros.



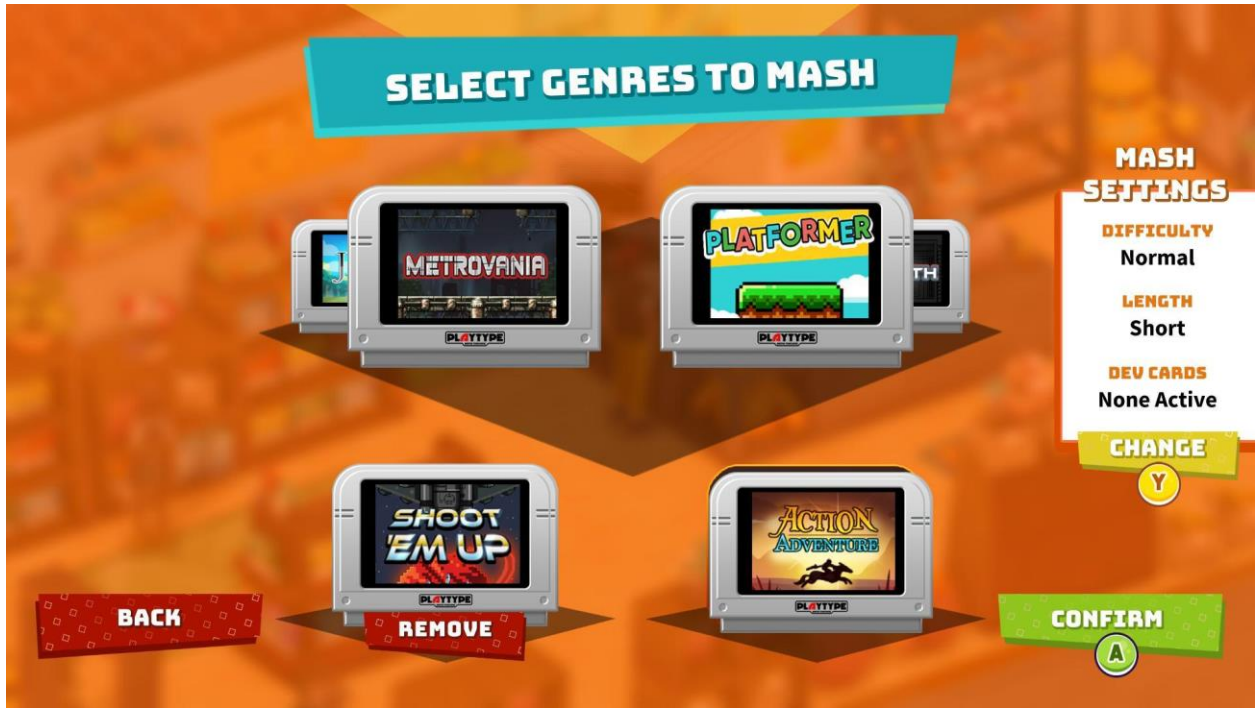
Rogue

Spelunky

Why GDCML?

- Combinational creativity evident throughout history of games

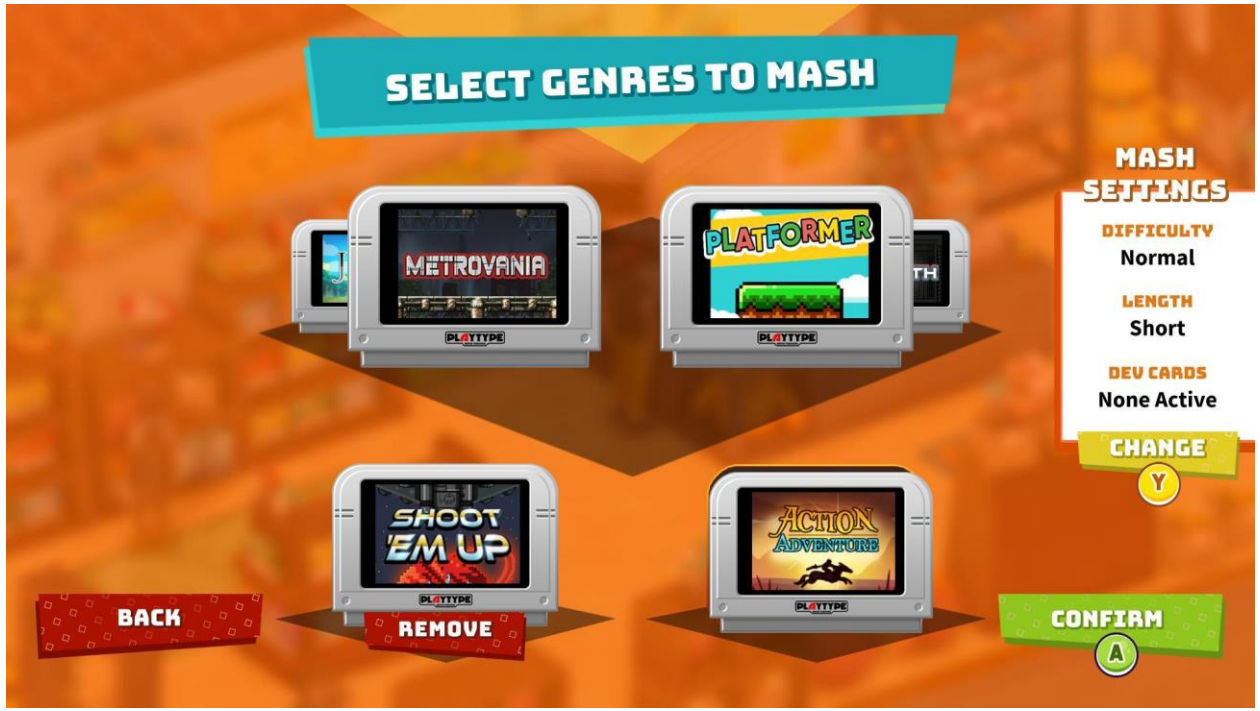
- *SuperMash* allows players to explicitly combine different genres to produce new games



SuperMash, source:gamespot.com

Why GDCML?

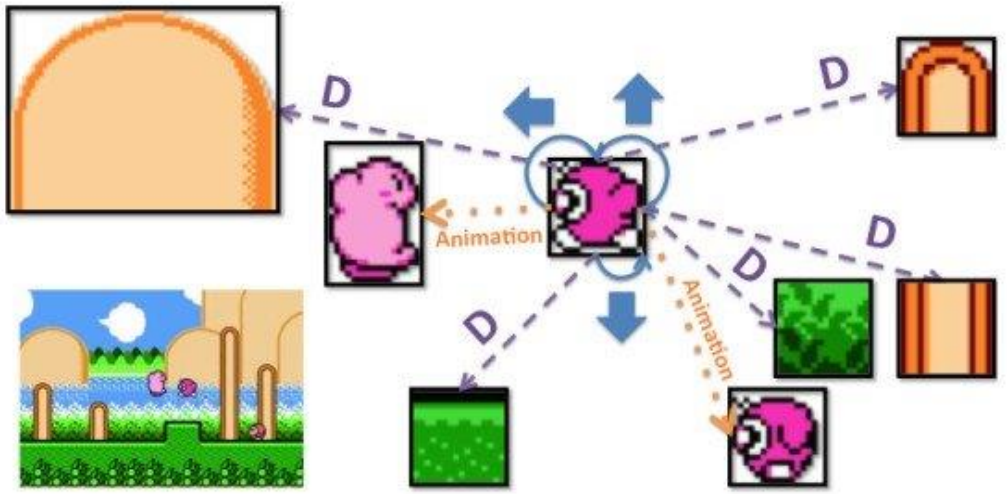
- Combinational creativity evident throughout history of games
- *SuperMash* allows players to explicitly combine different genres to produce new games
- Incorporating combinational creativity into PCGML models could enable tools to assist in such creative forms of game design and generation



SuperMash, source:gamespot.com

GDCML

- Creative PCGML
  - Guzdial and Riedl's *conceptual expansion* for auto-generating new games from existing games



Guzdial and Riedl, 2018

GDCML

- Creative PCGML
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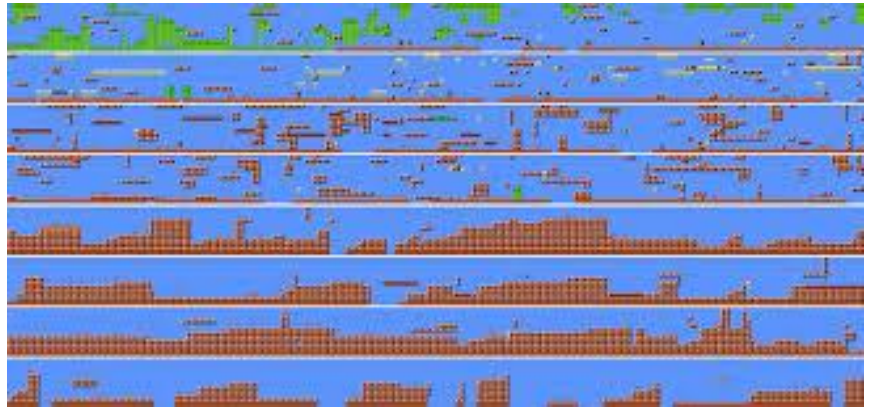
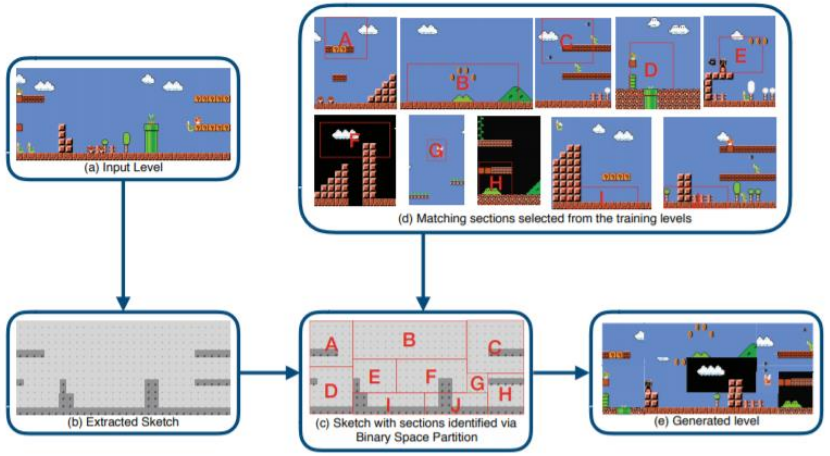
  - Snodgrass and Ontanon's domain transfer work and Snodgrass' BSP-based level generation



Snodgrass and Ontanon, 2016



Snodgrass, 2019

GDCML

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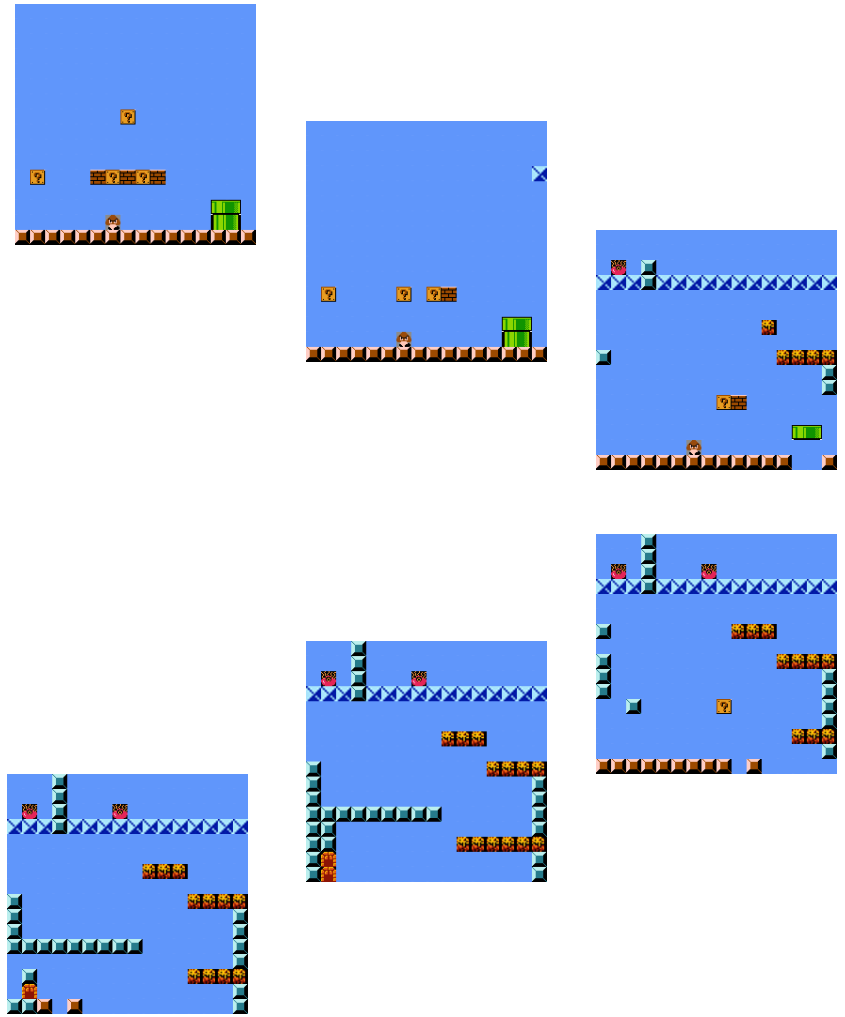

Sarkar et al., 2019

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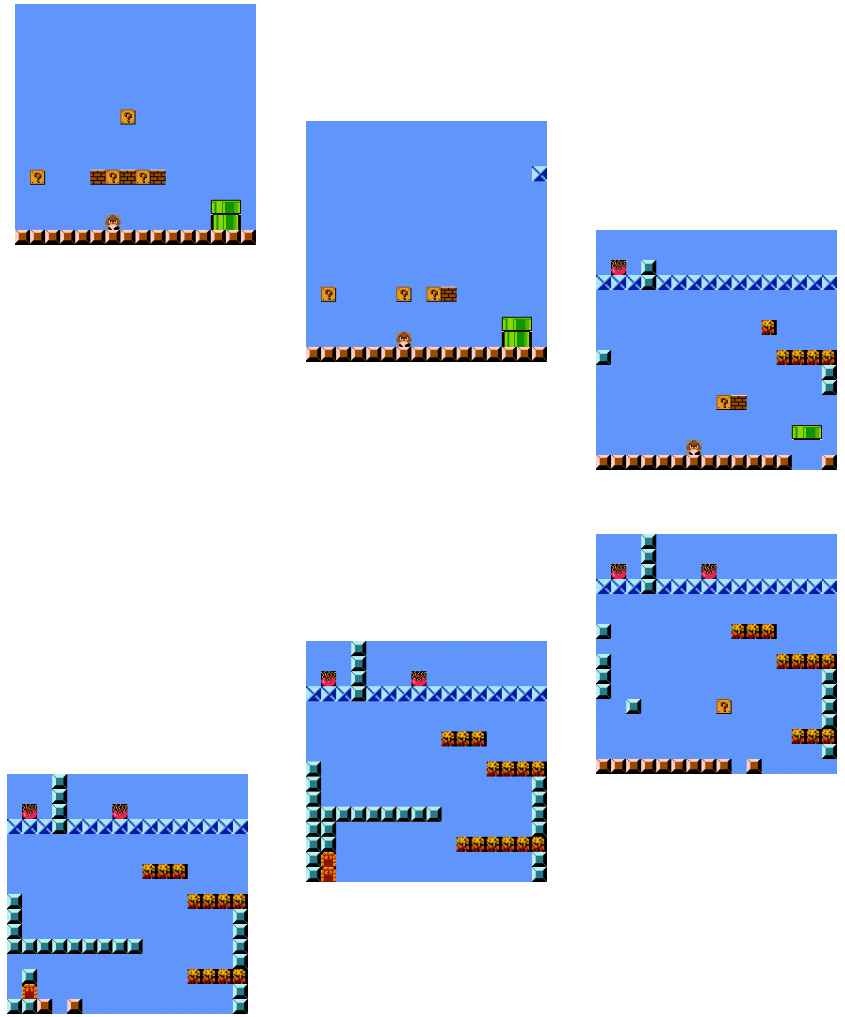

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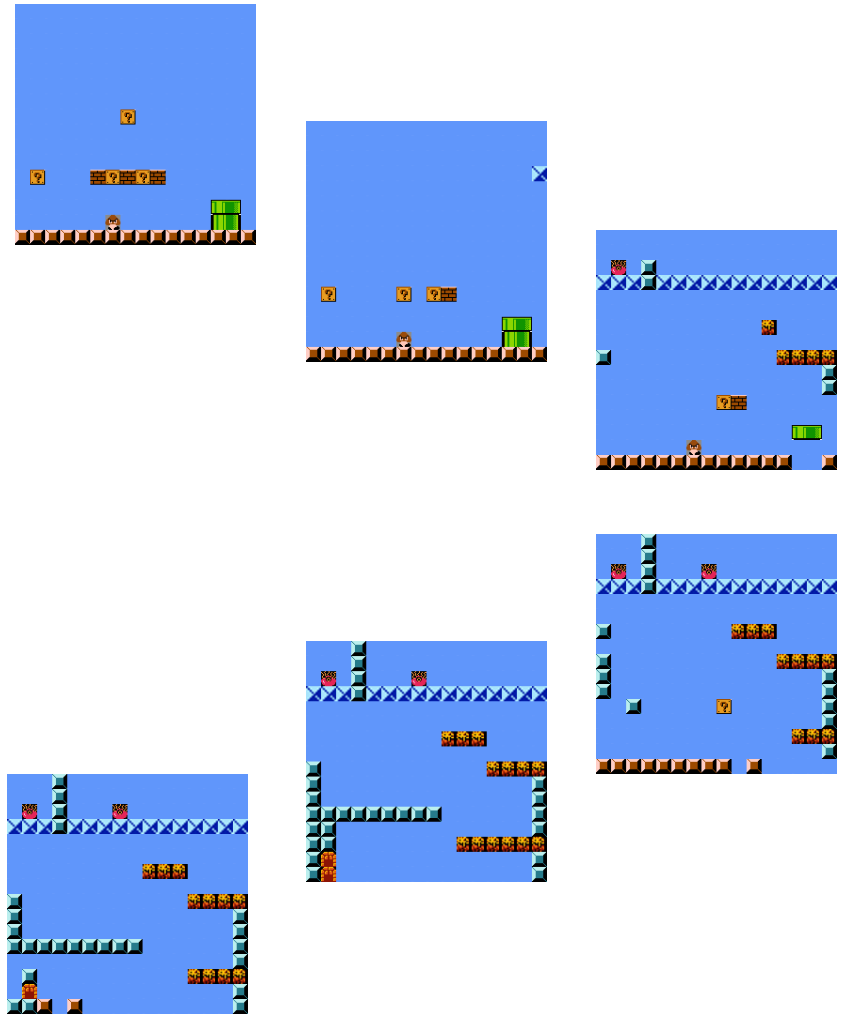
- Enable similar affordances within games as in art/music and prime these methods for serving as the foundation for co-creative GDCML tools



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Tools and Systems

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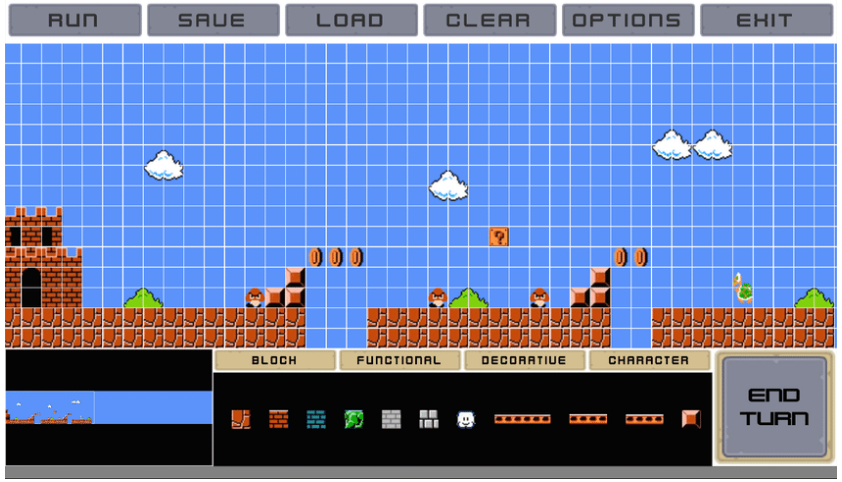

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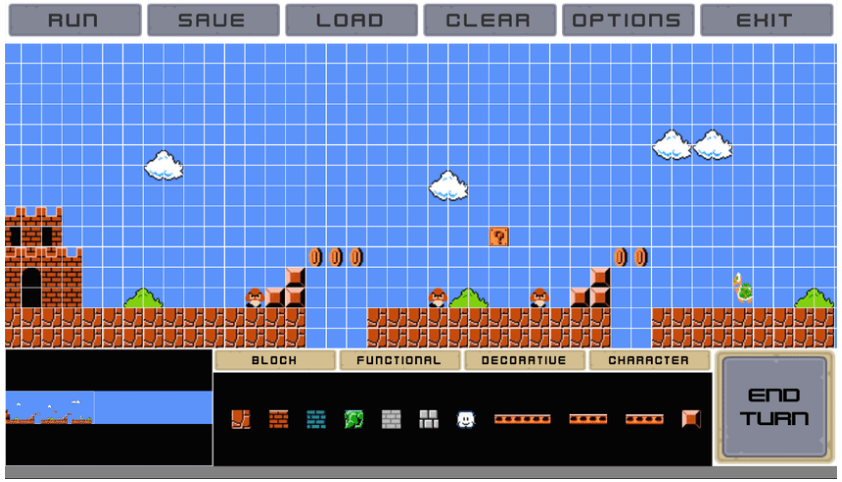

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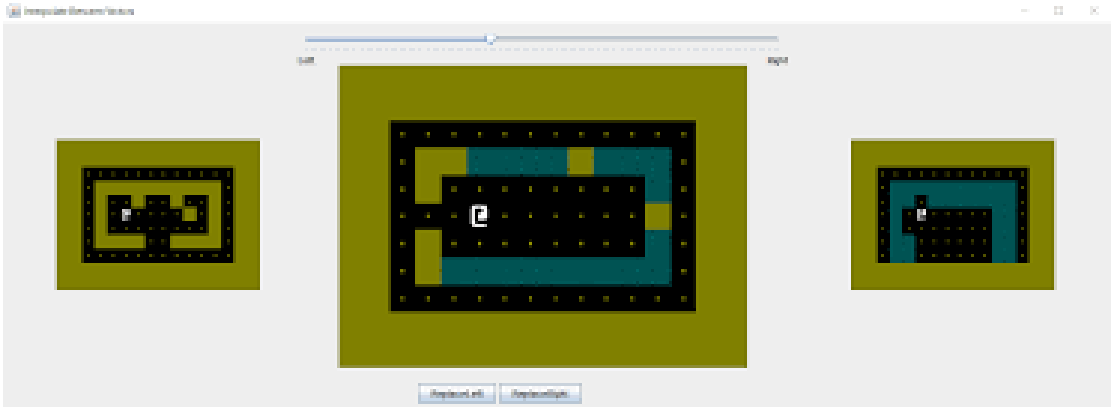

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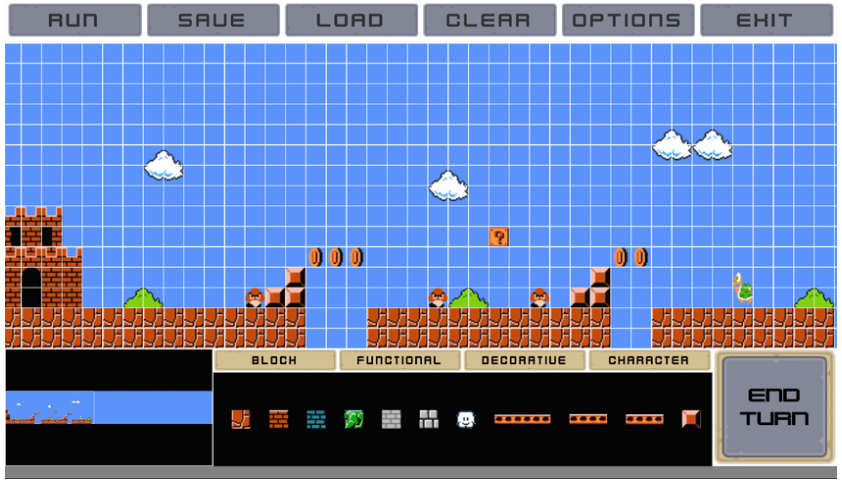

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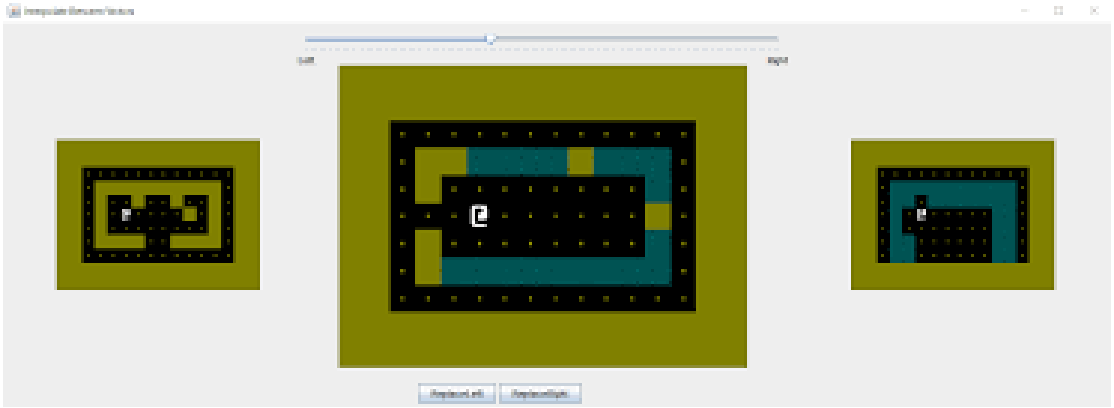

Schrum et al., 2020

- First steps towards realizing GDCML tools but
  - Restricted to a single domain or genre
  - Do not use more recent creative PCGML methods

Tools and Systems

- Build tools that leverage existing creative PCGML works to enable more creative applications in game design such as style transfer and design/discovery of new domains/genres of games

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- Build tools that leverage existing creative PCGML works to enable more creative applications in game design such as style transfer and design/discovery of new domains/genres of games

- Borrow and repurpose creative ML ideas/concepts/models from visual art and music into games

Applications

- Example applications to implement and operationalize in future GDCML tools

- Example levels taken from prior works utilizing variational autoencoders trained on levels from Super Mario Bros. and Kid Icarus

Game Blending

- Combining the levels/mechanics of two or more existing games to produce an entirely new game

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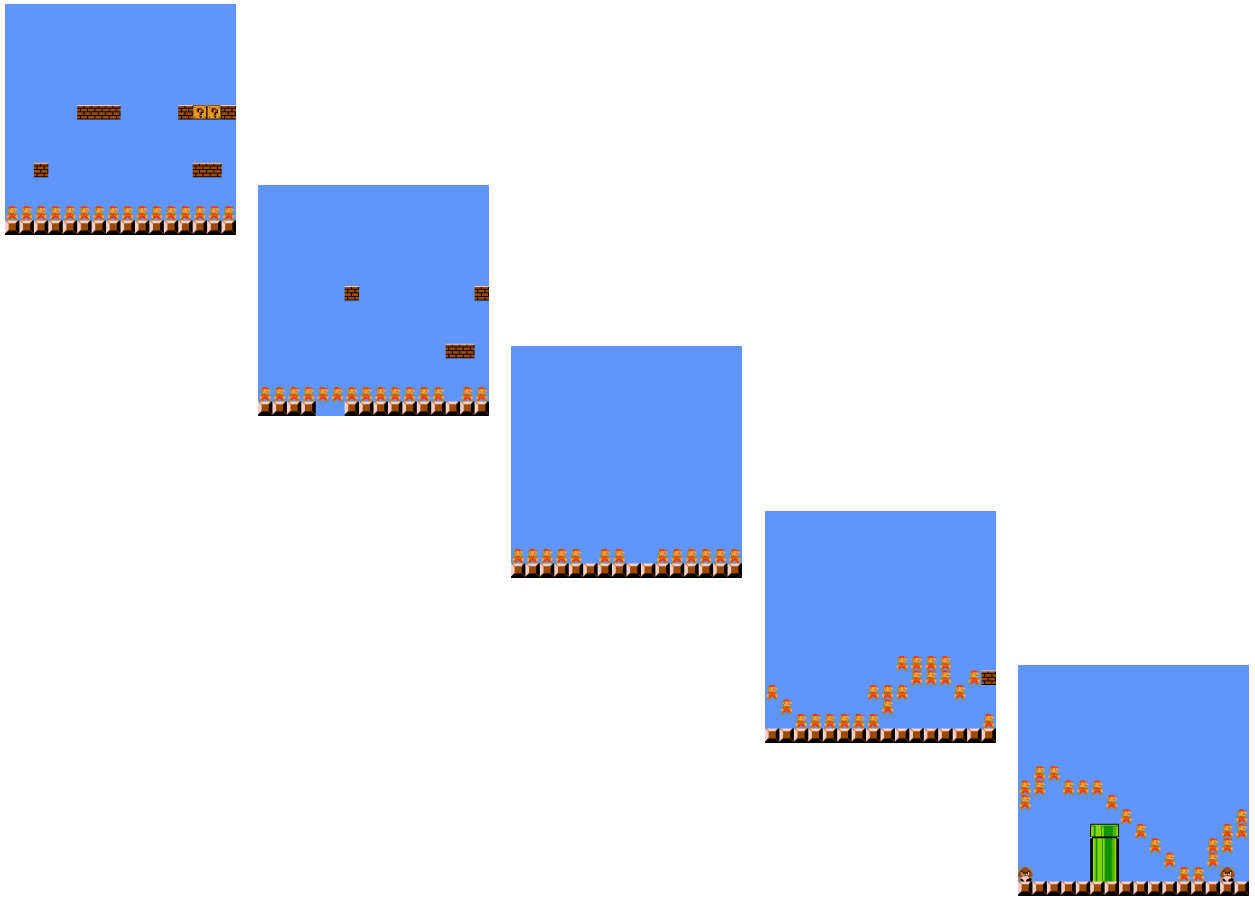
- Combining the levels/mechanics of two or more existing games to produce an entirely new game
- Prior work demonstrated the feasibility of using VAEs to blend levels from separate games
- A latent model trained on levels from multiple games learns a representation spanning all the games; levels generated using this representation blend properties of original games
- Enable users to blend levels and games as well as control blend amounts and properties

Interpolation

- Latent models learn encodings of data in a continuous, latent space



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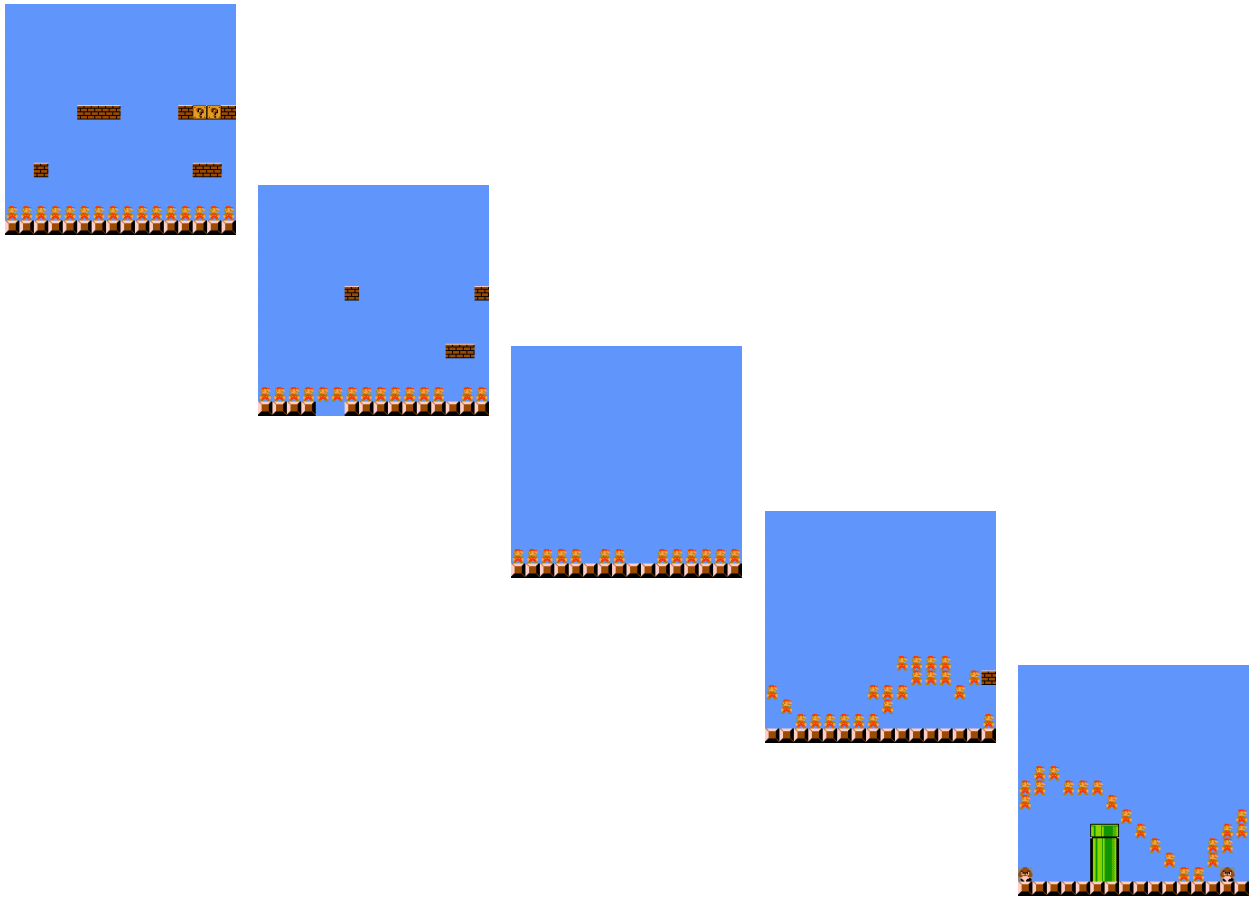

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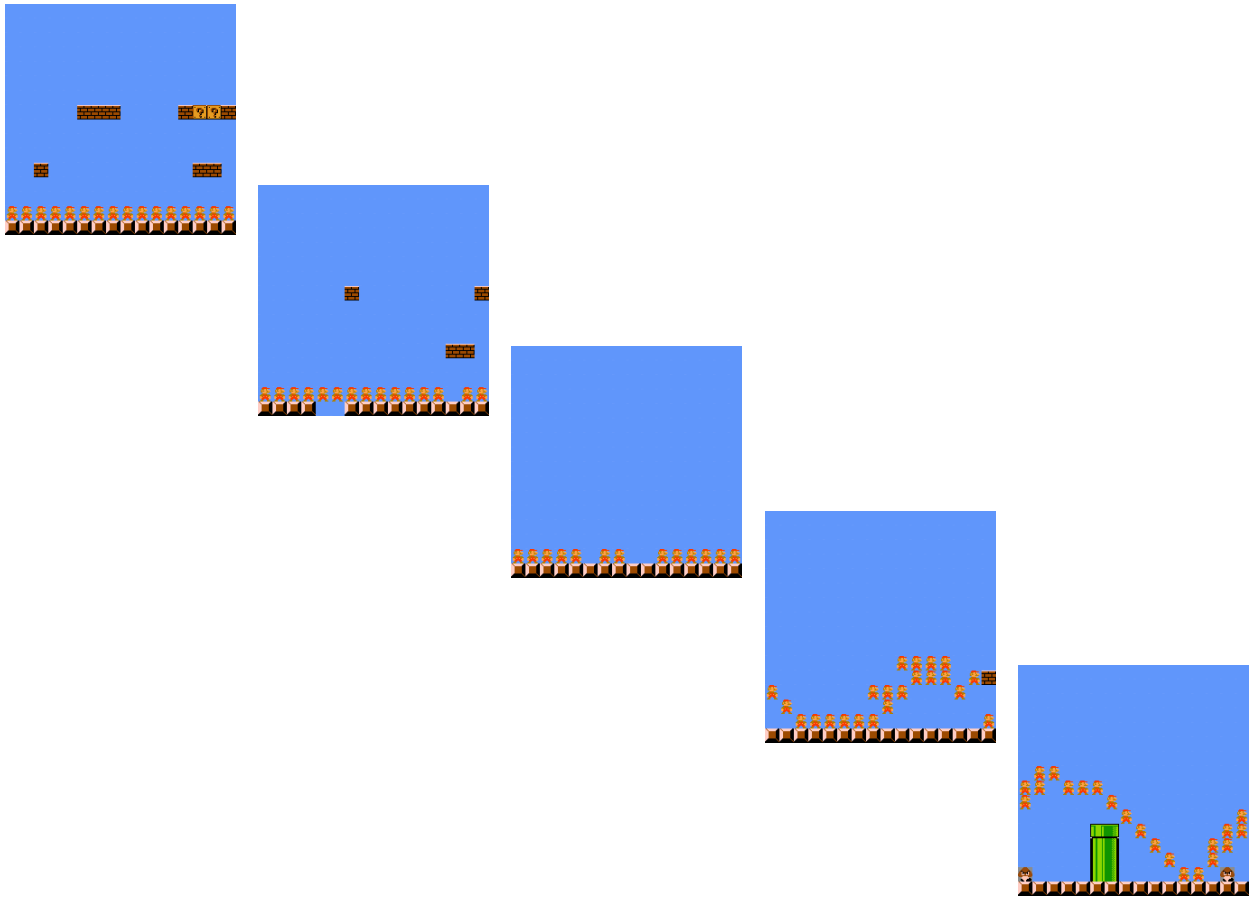

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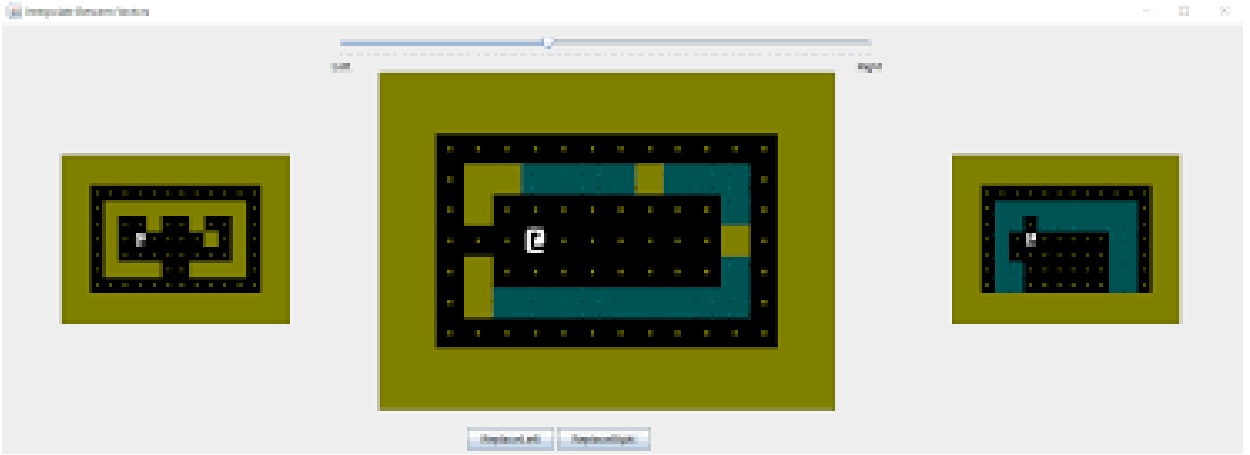
- Schrum et al.'s GAN-based tool implements interpolation between 2 levels of Mario/Zelda using a slider



Schrum et al., 2020

Level Search

- Search for new levels given an input level and an objective
- Queries of the form:
  - *Generate new level given input level X, metric Y and comparison condition Z*
- Enables generation of levels similar/dissimilar to an input level given a desired metric

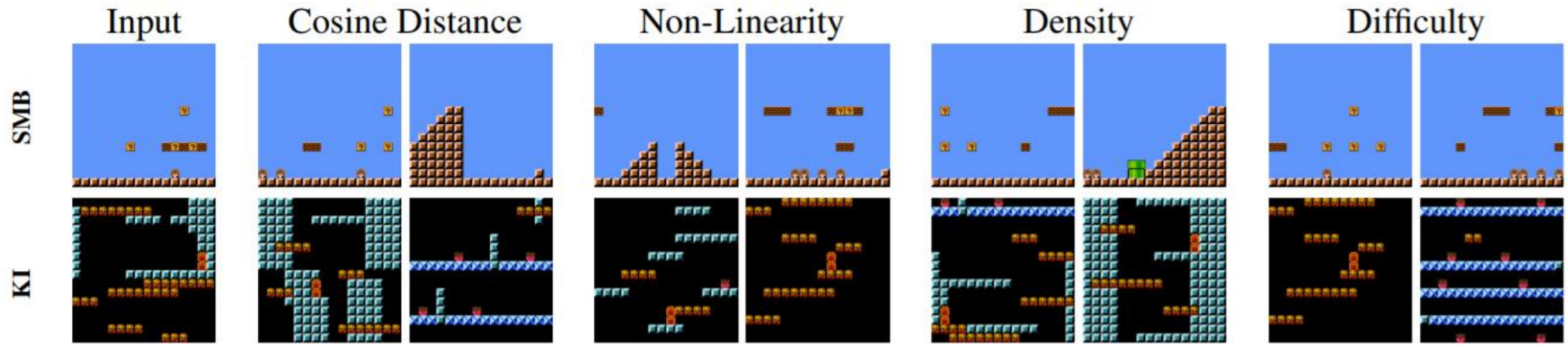


Figure 1: Reverse level search on training segments using the given input segment. Pairs consist of the closest match on the left and farthest match on the right based on the corresponding metric.

Sarkar, 2019

Conditioned Generation

- Controllability by conditioning generation on either an input segment or a label

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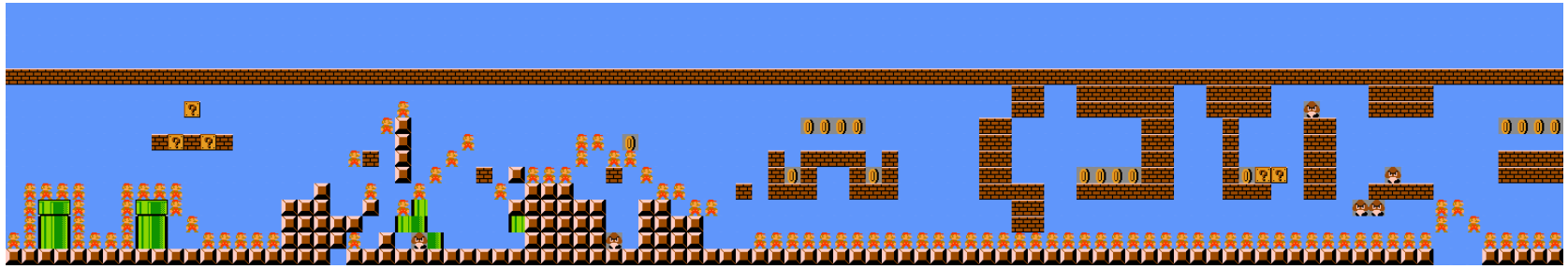
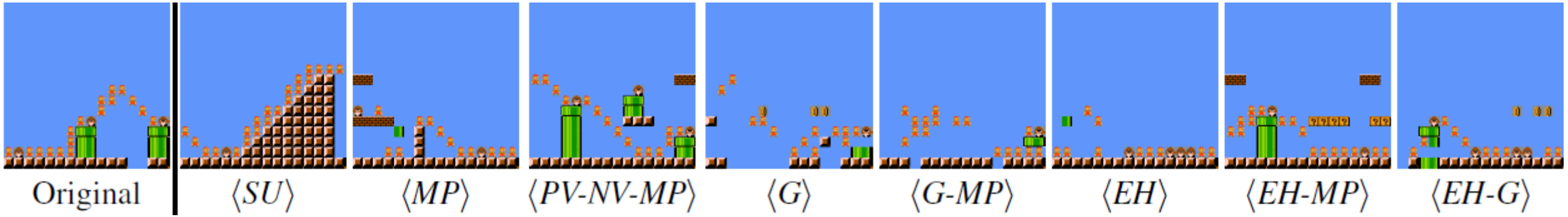


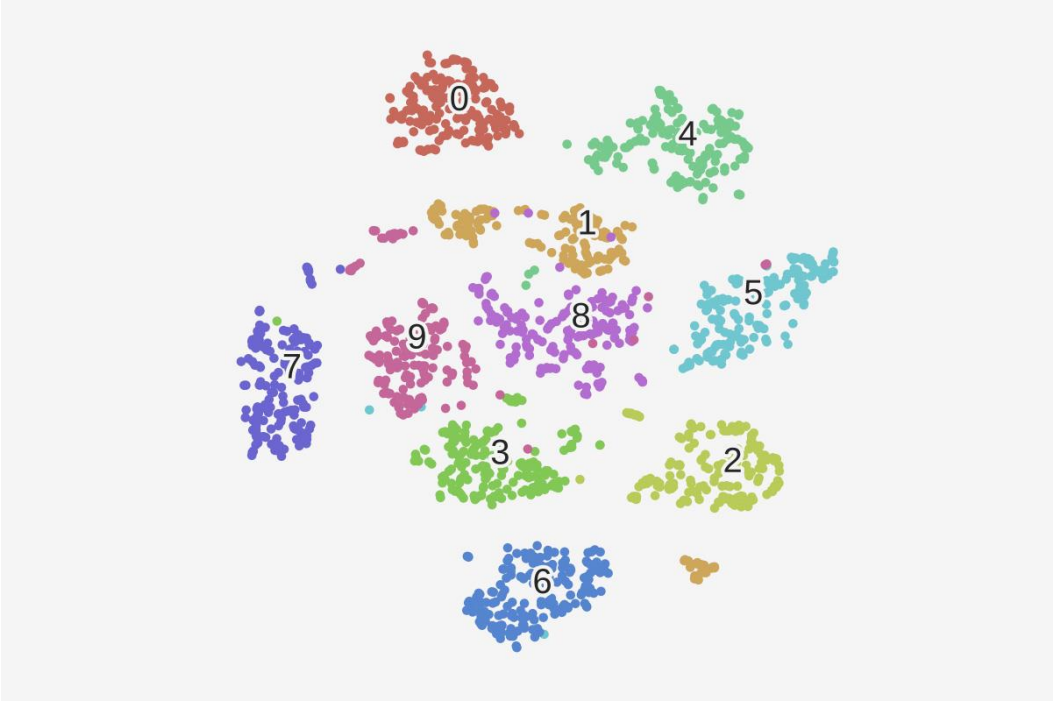
Conditioned Generation

- Controllability by conditioning generation on either an input segment or a label
- *Sequential Model* - predicts the next segment of a level given the current segment
- *Conditional Model* - generation conditioned on provided labels can allow users to generate new levels by using labels corresponding to different attributes



Latent Space Visualization

- Dimensionality reduction techniques like t-SNE can help visualize high-dimensional spaces



Source: oreilly.com

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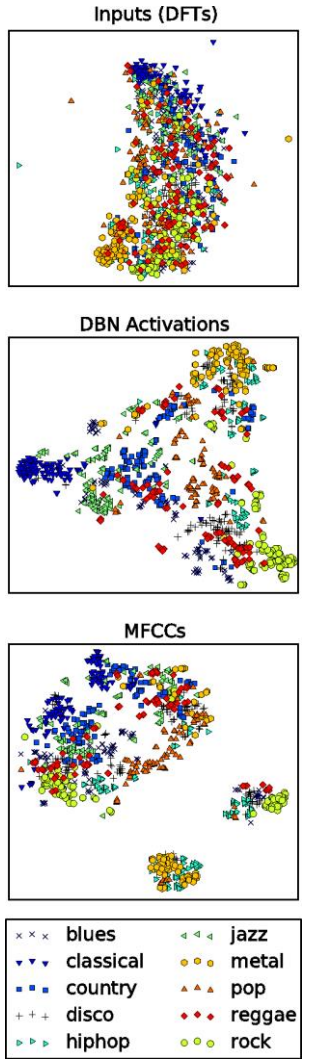
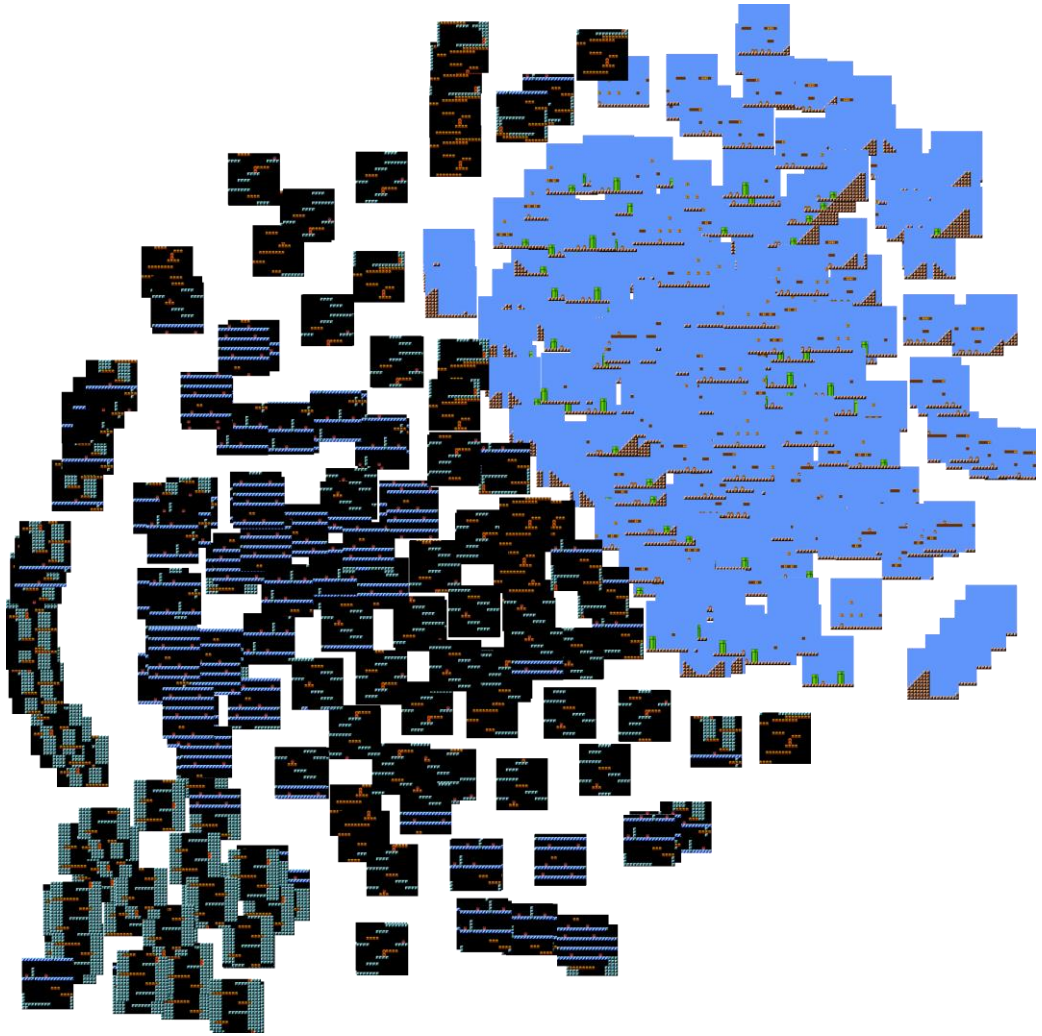
- Used to cluster images, paintings, audio clips based on features



Hamel and Eck, 2010

Latent Space Visualization

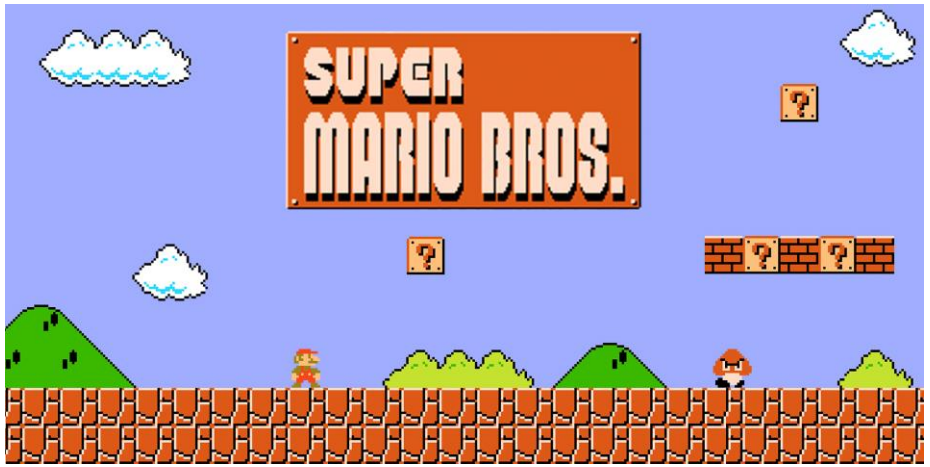
- Dimensionality reduction techniques like t-SNE can help visualize high-dimensional spaces
- Used to cluster images, paintings, audio clips based on features
- Interactive versions of visualizations of models trained on levels could allow designers to explore the learned latent space and search for desired content



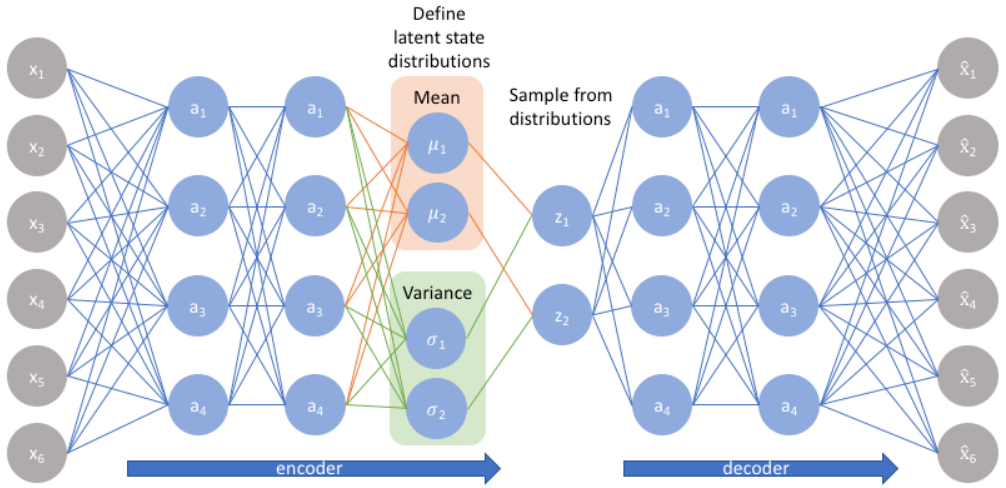
Proposed GDCML System

- Games
  - 2D side-scrolling platformers

- Models
  - Single-domain VAE models for each game
  - Multi-domain VAE models trained on all games taken together
  - Standard VAEs
  - Conditional VAEs
  - VAE-based Sequential Model



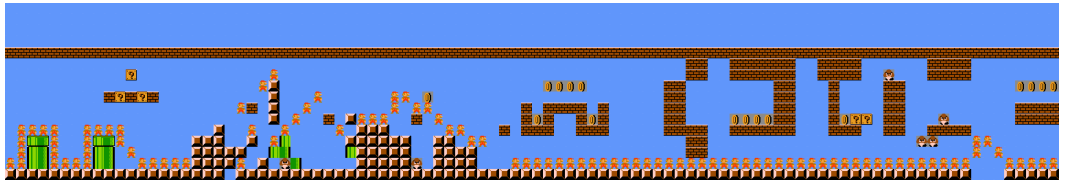
source: nintendo.co.uk



VAE Architecture, source: jeremyjordan.me

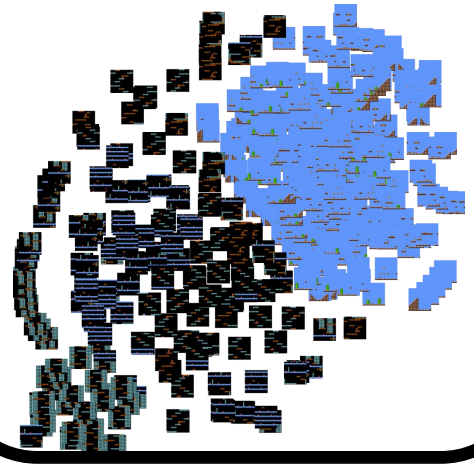
Proposed GDCML System

Continue

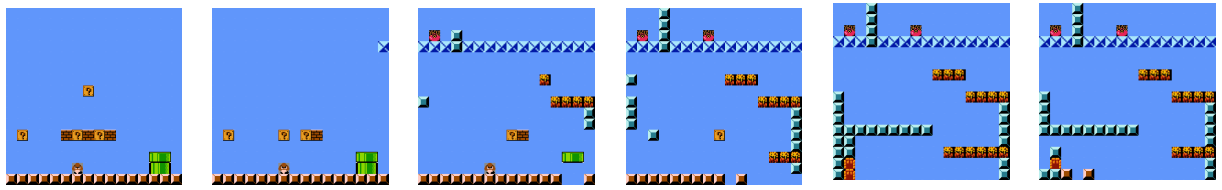


Blender

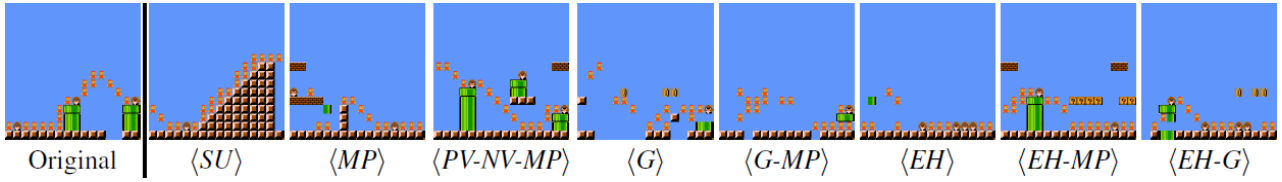
Visualizer



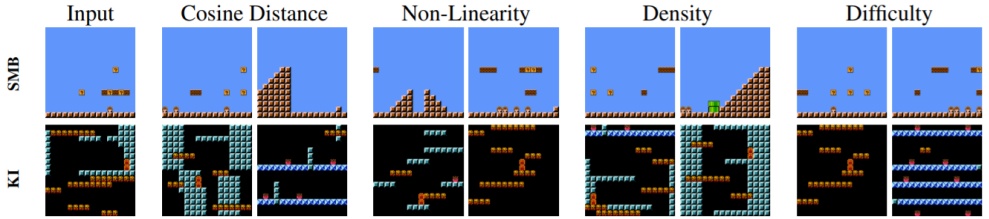
Interpolate



Condition



Search



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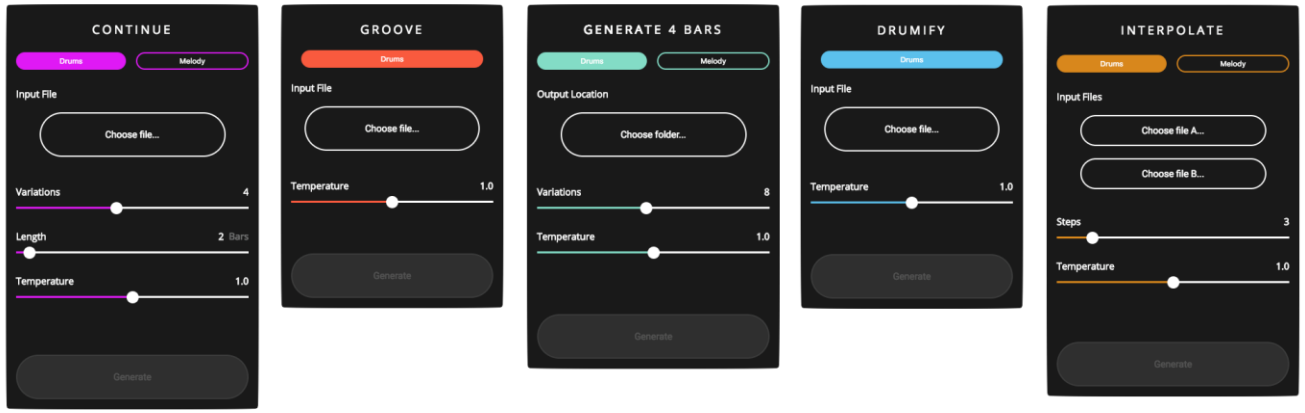
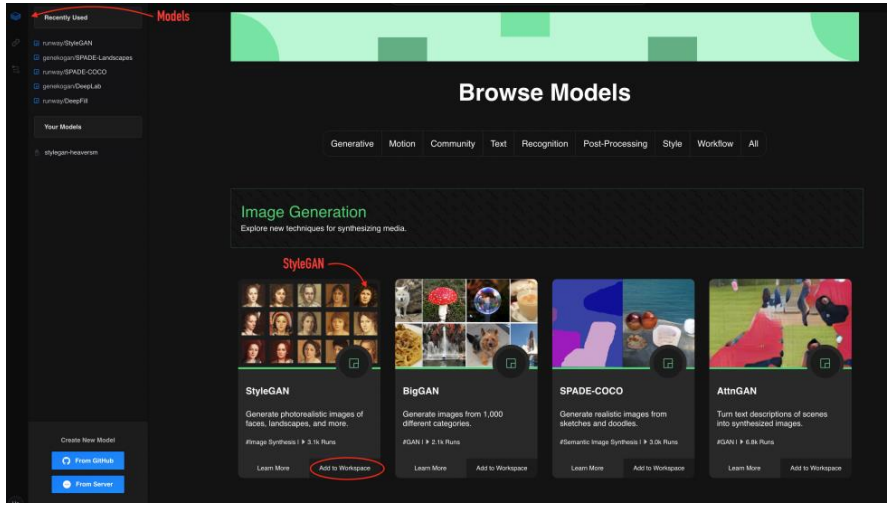
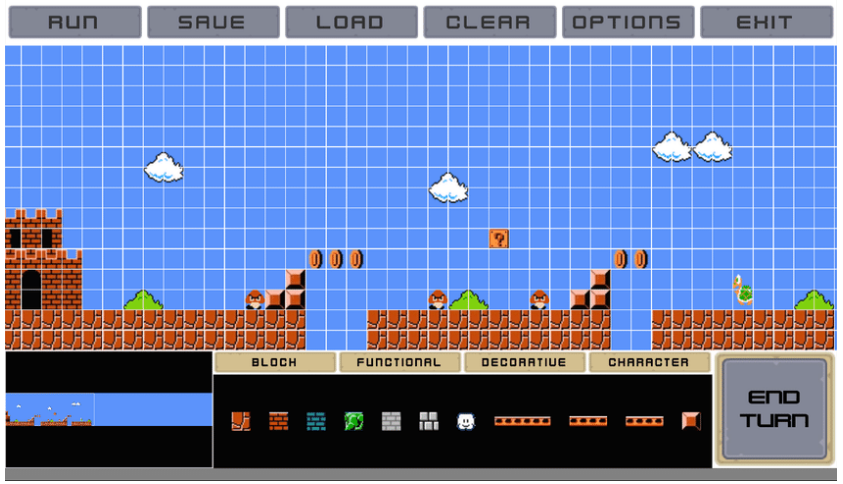


Magenta Studio, Roberts et al., 2019



RunwayML, source: heartbeat.fritz.ai



Morai Maker, Guzdial et al., 2018

Future Work

- Latent Space Disentanglement

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- Latent Space Disentanglement
- Datasets

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- Datasets
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Contact

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