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
Motivation

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• Visual Art
  • Style transfer
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• Music
  • Generation
  • Blending of styles and genres

MusicVAE, Roberts et al., 2018

Coconet, Huang et al., 2019
Motivation

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

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

  • Music
    • Generation
    • Blending of styles and genres

• However such ML-based creative approaches haven’t been widely adopted for game design
Motivation
• PCGML methods have demonstrated feasibility of ML for generating game content

Snodgrass and Ontanon, 2017
Volz et al., 2017

Summerville and Mateas, 2016
Guzdial and Riedl, 2016
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

Summerville and Mateas, 2016

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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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**Summerville and Mateas, 2016**

**Guzdial and Riedl, 2016**

**Snodgrass and Ontanon, 2017**

**Volz et al., 2017**
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
Creative ML for Visual Art

• Creative applications of ML for visual art
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• Interactive tools and applications
  • Neural Doodle
  • GAN Paint

Neural Doodle, Champandard, 2016

GANPaint, Bau et al., 2018
Creative ML for Visual Art

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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

MusicVAE, Roberts et al., 2018
Creative ML for Music

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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?

- Could we implement such creative ML applications in game design?
Creative ML for Games?

• Could we implement such creative ML applications in game design?

• Requirements
  • Build-on and extend existing PCGML models and methods
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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)
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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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- Interested in existing and potential approaches that could leverage PCGML methods to produce GDCML tools
Why GDCML?

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

Snodgrass and Ontanon, 2016

Sarkar and Cooper, 2020

Guzdial and Riedl, 2018
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Sarkar and Cooper, 2020

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- 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

1. Super Mario Bros. + The Legend of Zelda = Super Metroid
2. 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

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*Snodgrass and Ontanon, 2016*

*Snodgrass, 2019*
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*Sarkar et al., 2019*
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• Similar to approaches discussed previously for visual art and music
  • Learn models/representations of games
  • Use them to create new games/domains

*Sarkar et al., 2019*
GDCML

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• Similar to approaches discussed previously for visual art and music
  • Learn models/representations of games
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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

*Sarkar et al., 2019*
Tools and Systems

• Guzdial et al.’s *Morai Maker* – a Unity tool for designing Mario levels using PCGML models as co-creative partners

*Morai Maker, Guzdial et al., 2018*
Tools and Systems

- Guzdial et al.’s Morai Maker – a Unity tool for designing Mario levels using PCGML models as co-creative partners

- Schrum et al.’s co-creative design tool based on GAN models of Mario and Zelda

Morai Maker, Guzdial et al., 2018

Schrum et al., 2020
Tools and Systems

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

• 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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Game Blending

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• 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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  • Different games → blended levels for potential new game
  • Different levels of same game → new levels for that game
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  • Different levels of same game $\rightarrow$ new levels for that game

• 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
Conditioned Generation

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- *Sequential Model* - predicts the next segment of a level given the current segment
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
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

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

Interpolate

Condition

Blender

Visualizer

Search
Proposed GDCML System

Magenta Studio, Roberts et al., 2019

RunwayML, source: heartbeat.fritz.ai

Morai Maker, Guzdial et al., 2018
Future Work

- Latent Space Disentanglement
Future Work

• Latent Space Disentanglement
• Datasets
Future Work

• Latent Space Disentanglement

• Datasets

• Blending Genres
Future Work

• Latent Space Disentanglement
• Datasets
• Blending Genres

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