Exploring Level Blending across Platformers via Paths and Affordances

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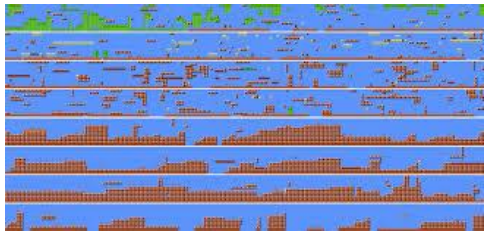
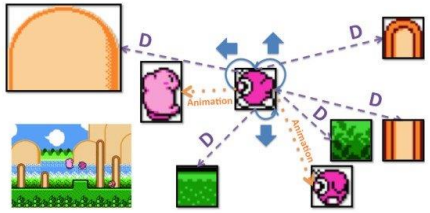
Introduction

- Recent trend of creative PCGML focused on learning models for generating content outside of training domain



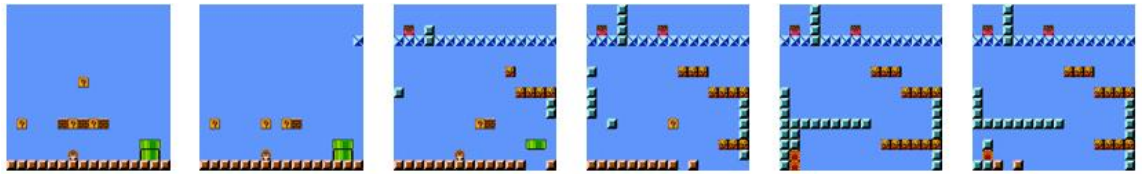
Snodgrass and Ontanon, 2016

- Techniques include
  -- Domain transfer
  -- Combining learned models
  -- Building game graphs using learned models
  -- Learning new blended domains



Guzdial and Riedl, 2018

Contribution



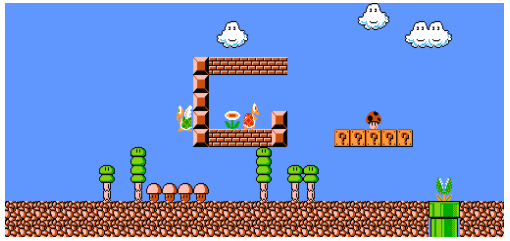
Sarkar, Yang and Cooper, 2019

- We extend prior work (above) in learning blended domains using variational autoencoders (VAEs) by
  --- Increasing input domain from 2 to 6 games
  --- Introducing a new affordance vocabulary to unify game representations
  --- Incorporating paths to generate blended levels that are playable
  --- Introducing the use of GRU-VAE for PCGML

Games

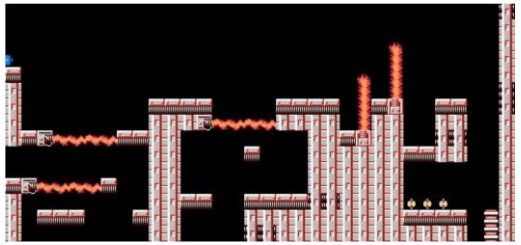
- Increase input domain for blending from 2 to 6 games
- Greater possibility space for blending

Super Mario Bros.

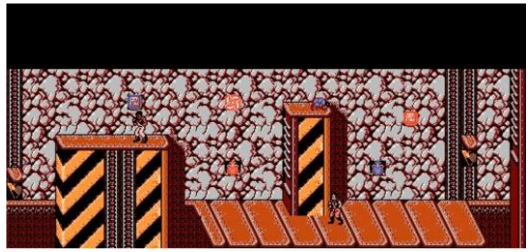


Super Mario Bros. II: The Lost Levels

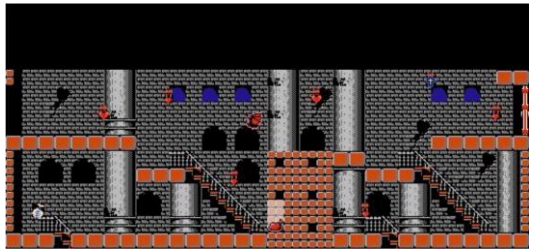
Metroid



Mega Man



Ninja Gaiden



Castlevania

Affordances

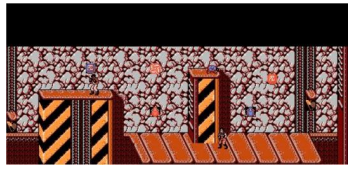
- Introduced a new unified affordance vocabulary based on Video Game Affordance Corpus (Bentley and Osborn, 2019)

X: *solid*, (e.g., ground or platforms)
S: *solid, breakable*, (e.g., breakable bricks in *SMB*)
#: *solid, moving*, (e.g., moving platforms)
|: *solid, passable, climbable*, (e.g., ladders)
v: *hazard*, (e.g., spikes)
^: *solid, hazard*, (e.g., lava or solid spikes)
e: *moving, hazard*, (e.g., enemies)
E: *solid, moving, passable, hazard*, (e.g., enemies the player could pass through or jump on)
o: *collectable*, (e.g., coins)
*: *collectable, powerup*, (e.g., weapon refills in *MM*)
Q: *solid, collectable*, (e.g., coin blocks in *SMB*)
!: *solid, powerup*, (e.g., mushroom blocks in *SMB*)
$: *portal*, (e.g., doors in *Metroid*)
@: *solid, null, hazard*

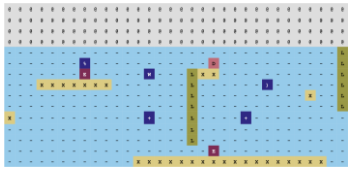
Ninja Gaiden

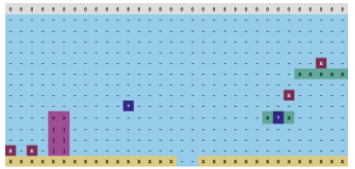
Super Mario Bros.

Original

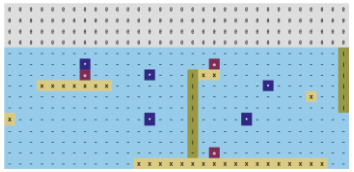


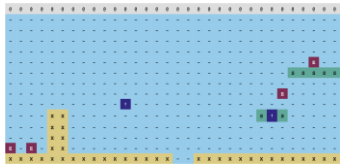
Domain Specific





Unified

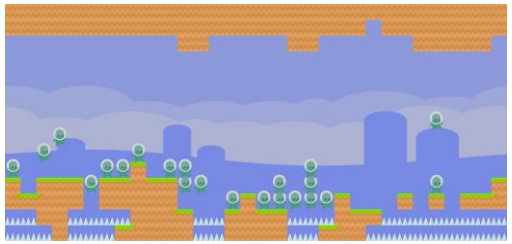


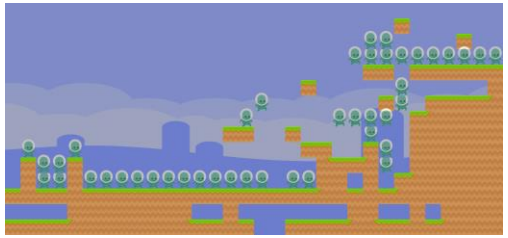


Paths

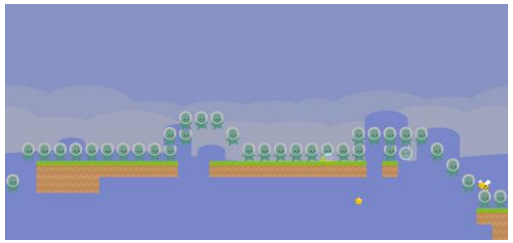
- Incorporated paths generated by A* agents tuned using jump arcs for each game
- Captures gameplay behavior/mechanics in addition to level structure
- Helps generate playable blended levels

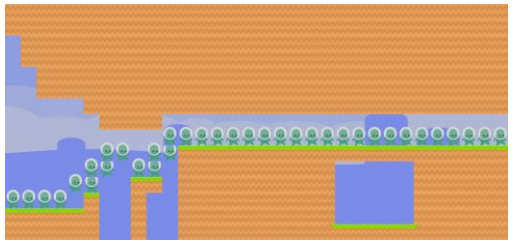
Sample Generations





Linear-VAE Samples





GRU-VAE Samples

Models and Evaluation

- Two types of models
  - Linear-VAE – consisting of fully-connected linear layers
  - GRU-VAE – consisting of Gated Recurrent Unit (GRU) layers

- Four versions of each model differing in latent dimension size – 32, 64, 128, 256

- Two-part evaluation
  - Tile-based Metrics
    --- E-distance (measure of distribution similarity) between generated and original levels
    --- E-distance computed using: *Density, Nonlinearity, Leniency, Interestingness, Path-Proportion*

  - Agent-based Playability
    --- Fréchet distance (measure of path similarity) between A* agent paths and paths in generated levels

Results

Tile-based evaluation (E-distance)

Model	ALL	CV	MM	Met	SMB	NG
LIN32	*0.58*	1.66	*3.53*	12	4.76	3.88
-64	0.6	0.9	5.52	*10.6*	3.1	2.54
-128	0.99	*0.86*	6.58	13.72	3.25	*2.29*
-256	0.88	0.97	5.92	14.14	*3.00*	2.82
GRU32	2.28	1.22	4.16	**0.4**	0.38	**1.22**
-64	1.25	1.15	**2.4**	0.89	**0.34**	1.9
-128	0.46	0.76	5.08	2.45	2.07	1.36
-256	**0.32**	**0.66**	4.81	0.52	3.13	1.78

- GRU-VAE better at learning level structure and patterns (lower E-distance)

Agent-based evaluation (playability)

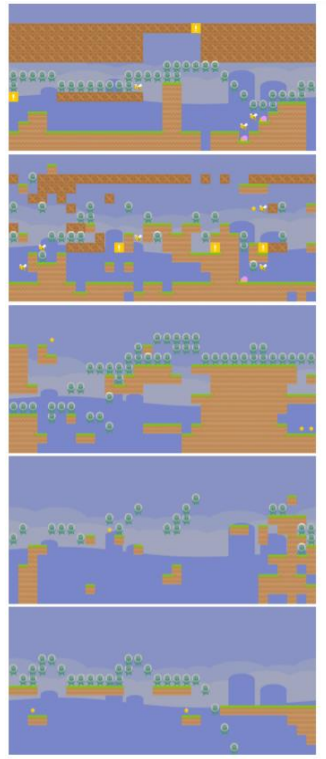
Model	Agent Failure Rate
LIN-32	11.46%
LIN-64	11.72%
LIN-128	*11.25%*
LIN-256	11.14%
GRU-32	**4.52%**
GRU-64	5.12%
GRU-128	4.81%
GRU-256	4.55%

- GRU-VAE produces more playable levels (~95%) compared to Linear-VAE (~89%)

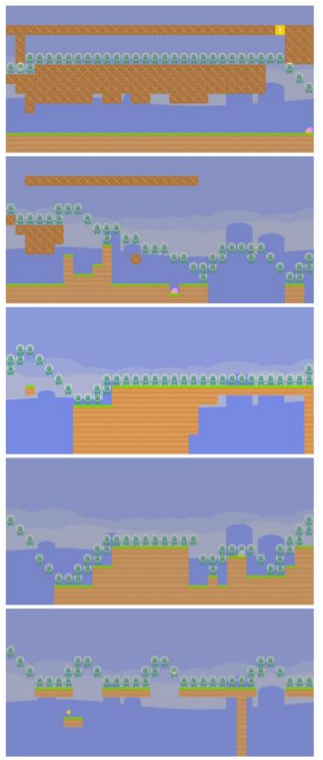
Qualitative Observations

- GRU-VAE produces less noisy levels and more continuous paths
- Linear-VAE produces more discernible interpolation with clearer blending

Sample Interpolations



Linear SMB ↓ MM



GRU SMB ↓ MM

Future Work

- Extracting blended physics from paths (Summerville et al., EXAG 2020)
- Vertical orientations
- Other genres