

# AI-based Game Design

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**UNIVERSITY  
OF ALBERTA**

# Announcements

- USRI's due next Monday. Please fill this out! (only at 10% completion right now)  
<https://p20.courseval.net/etw/ets/et.asp?nxappid=UA2&nxmid=GetSurveyForm&wsedrq=70PACSH034>
- Today: AI-based Game Design + Review
- Monday: Quiz 6 (RL in Games, Automated Game Playing, Dialogue and Narrative Generation, and today's lecture)
- Monday: Assignment 5 due (office hours right after class)

# A Little Background

Significantly, developers overall reported that AI was becoming a more important factor in game design than it had been in the past, often being assigned an equal priority with graphics and sound in the initial game design and allocation of resources. Those responsible for game AI (whether or not it is their sole

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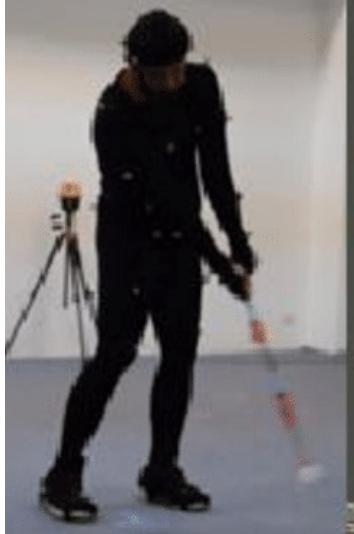
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Even when cutting AI techniques are used in game development, they're often to benefit graphics



Learned Motion Matching



Phase-Functioned Neural Network



But what if we lived in the world Steve  
Woodcock imaged in the 90s?

AI-based game design

# AI-based Game Design: What does this mean?

- Does it mean AI's making games all by themselves?
  - No, that's **Autonomous Game Design**.
- Does it mean AI's making games with humans?
  - No, that's **Co-creative or Mixed Initiative Design**.
- Does it mean games where the primary selling point is interaction with an AI system or systems?
  - Yes, why did it take you so long to guess this?

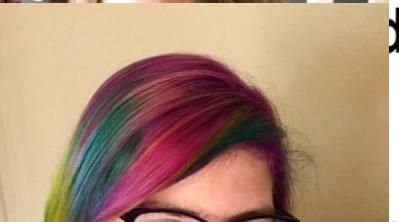
# AI-based Game Design Patterns?



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# Design Considerations for Creating AI-based Gameplay



Design Considerations for Creating AI-based Gameplay

**Ben Samuel<sup>1</sup>, Mike Treanor<sup>2</sup>, Joshua McCoy<sup>3</sup>**

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# AI-based Games Definition

“AI-based game is one where the mechanics, dynamics, and aesthetics of the game are deeply linked to the AI system.”

-Treanor et al.\*

<http://julian.togelius.com/Treanor2015AIBased.pdf>

# AI-based Games Definition 2

As physics-based games rely on a physics systems, AI-based games rely on AI systems

physics      artificial+intelligence      Search      Sort by Relevance ▾

5,791 results match these titles would appear

842 results match your search. 11 titles (including VR HOT) have been excluded based on your preferences.

⚙️ ▾

		WorldBox - God Simulator Windows, Apple, Key	2 Dec, 2021	CDN\$ 22.79
		AIPD - Artificial Intelligence Police Department Windows	28 Jan, 2016	CDN\$ 10.99
		Cricket 22 Windows	1 Dec, 2021	CDN\$ 49.99
		The Birth of an Artificial Intelligence Windows, Apple	11 Oct, 2021	CDN\$ 39.99
		The Birth of an Artificial Intelligence Soundtrack Musical Note	11 Oct, 2021	Free

# AI-Based Game Design Patterns

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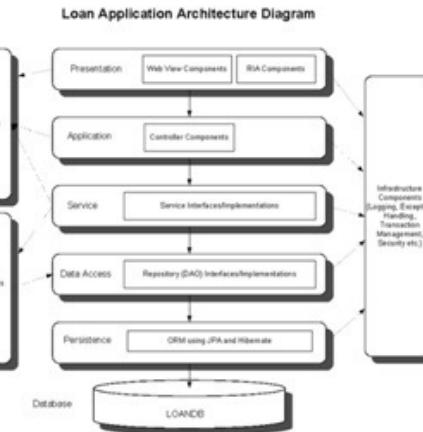
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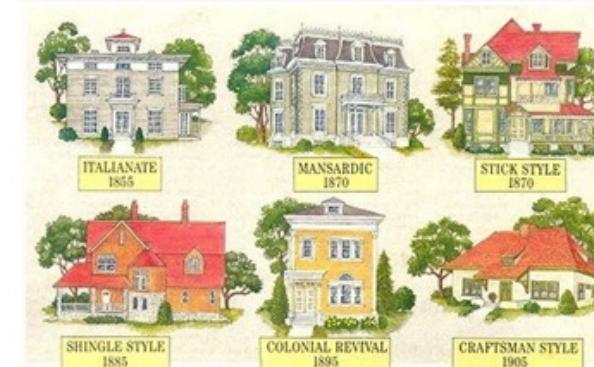
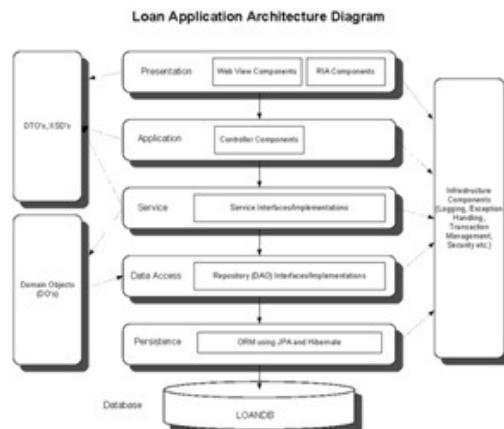
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# Christopher Alexander Design Patterns



## Architectural Design Patterns



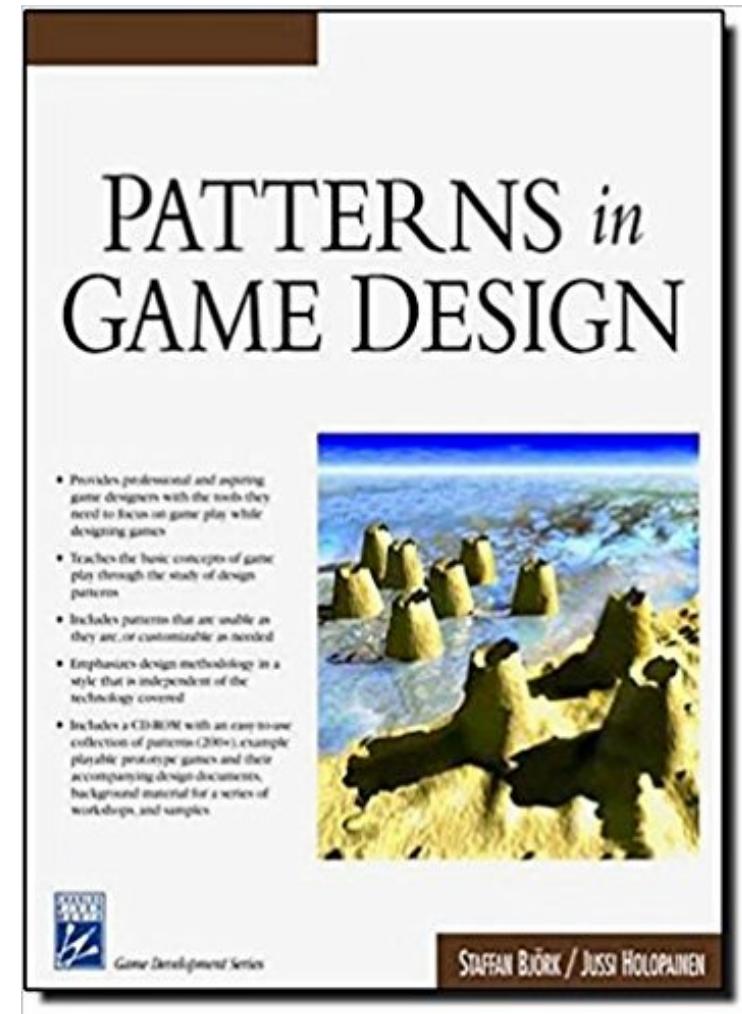
From Architecture -> To Software Engineering

# Game Design Patterns

## Björk and Holopainen

Hundreds of patterns to describe things like...

- Asymmetric Gameplay
- Cut scenes
- High Score Lists
- Enemies
- Etc.



# 9 AI-based Game Design Patterns identified by Treanor et al.

1. AI is Visualized: Observe/React to AI State
2. AI as Role-model: Imitate/Learn from AI
3. AI as Trainee: Teach the AI
4. AI is Editable: Edit the AI
5. AI is Guided: Guide/manage the AI
6. AI as Co-creator: Make artifacts assisted by AI
7. AI as Adversary: Typical enemy AI role
8. AI as Villain: Asymmetrical Adversary with *drama*
9. AI as Spectacle: Observe the AI

# AI-based Game Design Patterns

Many example games will have several patterns

Question: What does it mean for a game to have a pattern?

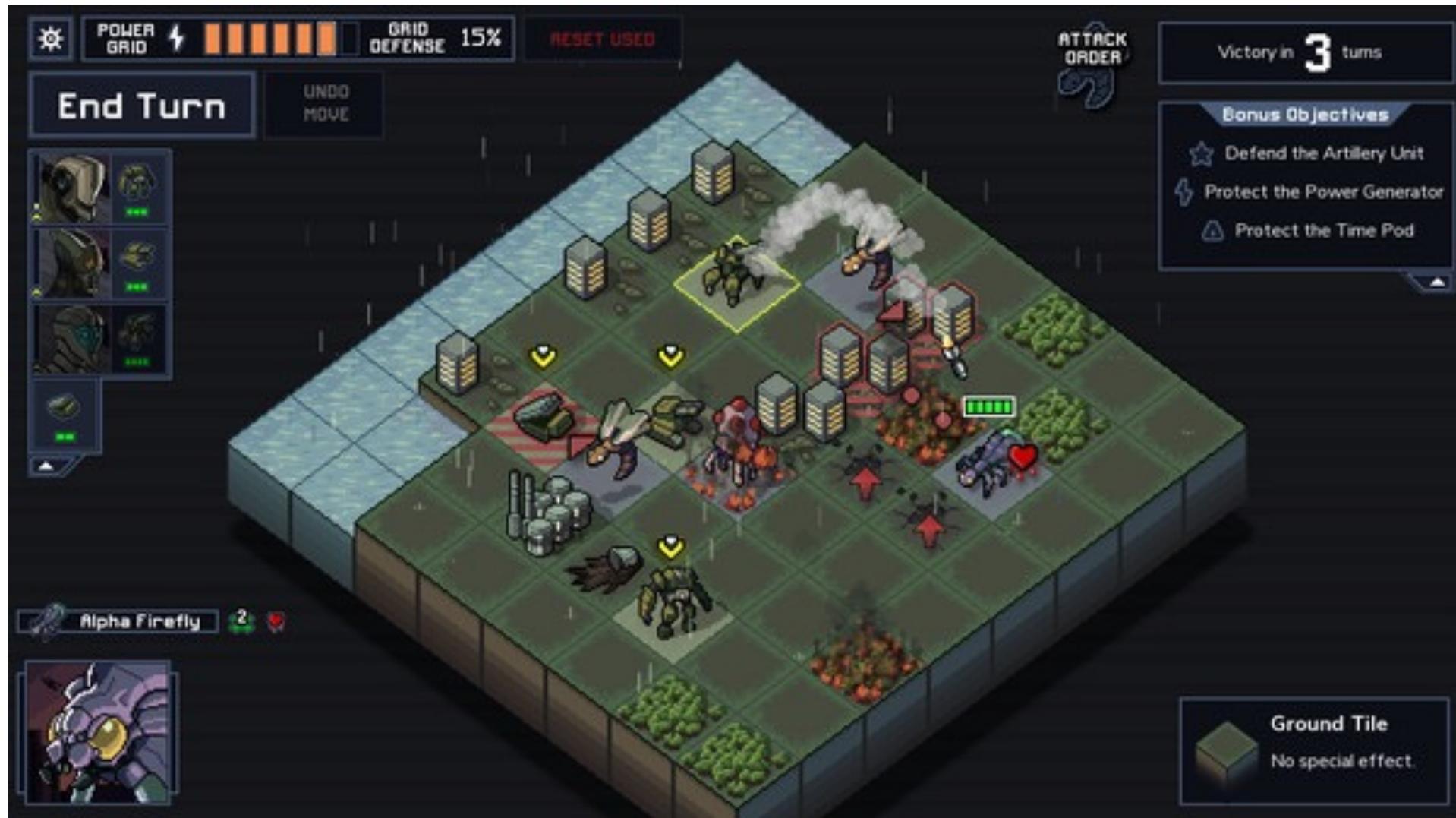
Answer: The game would not be the same game without that pattern for some players

- **Note:** This indicates some portion of players may never interact with the pattern.

# AI is Visualized: Third Eye Crime (2014)



# AI is Visualized: Into the Breach (2018)



# AI is Visualized/(Observable)

- Some subset of AI internal state is observable to human player
- Play arises from how the player utilizes this additional information
- Secondary example: F.E.A.R. grunts saying their plans through radio chatter
  - <https://www.youtube.com/watch?v=qX73XG9e5BE>

# AI is Visualized: Techniques

Easiest to imagine when the AI is a single embodied entity. Then one can visualize parts of the state:

- Paths: Next point in the path, entirety of the path, or goal of the path
- Current State (Finite State Machine): What the AI is trying to do

But could we do something more interesting?

Transition Variables (Finite State Machine): Can the player push the AI towards/away from a state

- Plan: What the AI's next action in the plan is or its goal

# Animation vs. AI is Visualized



The Walking Dead (2012), Telltale Games

<- There's no AI guiding this character, no internal representation of sadness. So not AI is Visualized.

# Animation vs. AI is Visualized



<- There's an internal representation of emotion for this Sim.

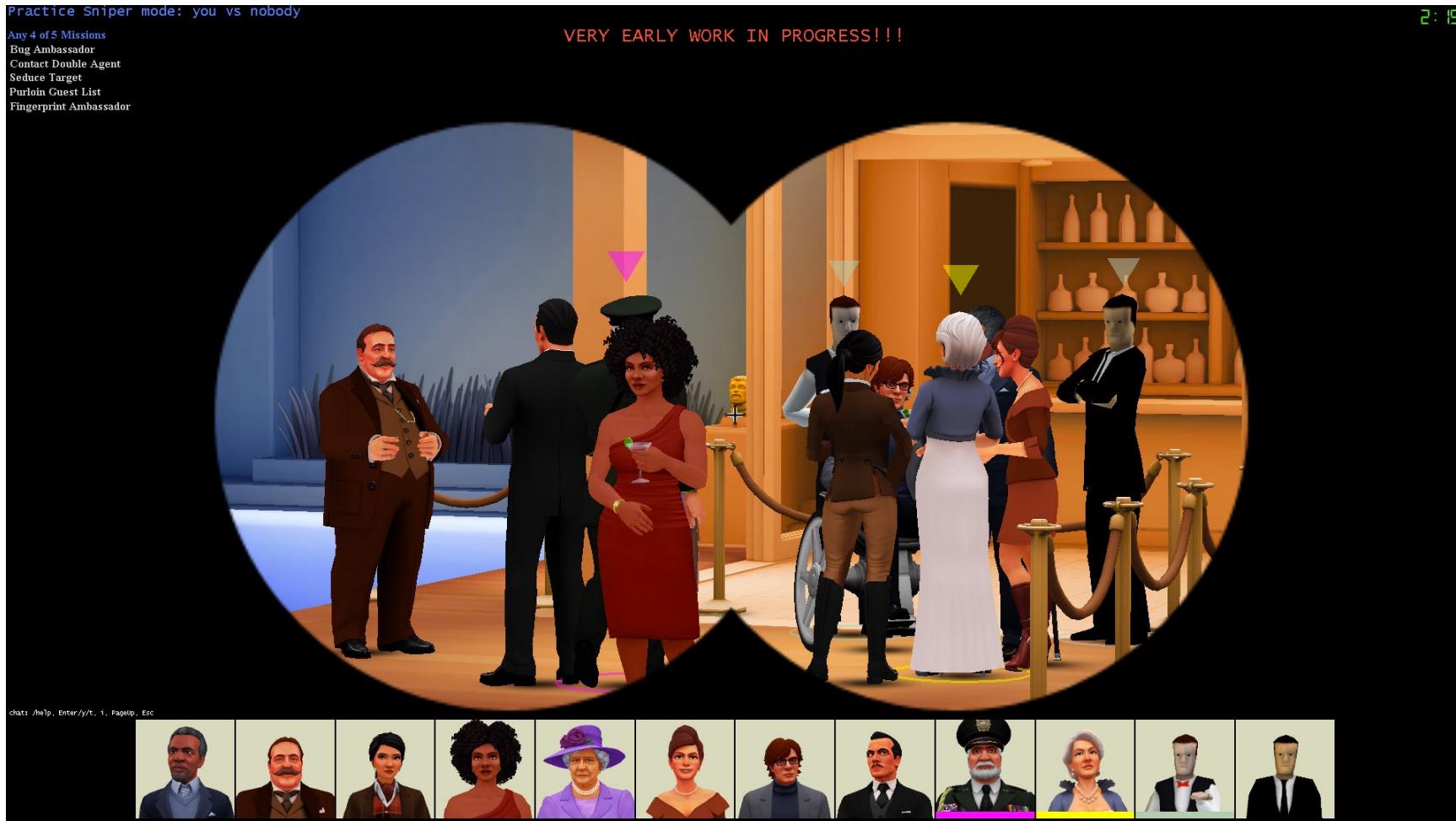
So this is AI is Visualized.

# AI is Visualized: Player Experience

- Novelty: Players don't typically get to see state visualized
- Problem Solving: Dependent on game design this information can impact player problem solving
- Player Goals: This information can create/alter player goals, pushing a player to play differently



# AI as Role-model: SpyParty (2018)



<https://www.youtube.com/watch?v=oUv0D2DPyJs>

# AI as Role-model

- AI agent(s) exist(s) in the game (typically hand-authored) for the player to model their behavior
- Play arises from how well the player can model the AI agent's behavior

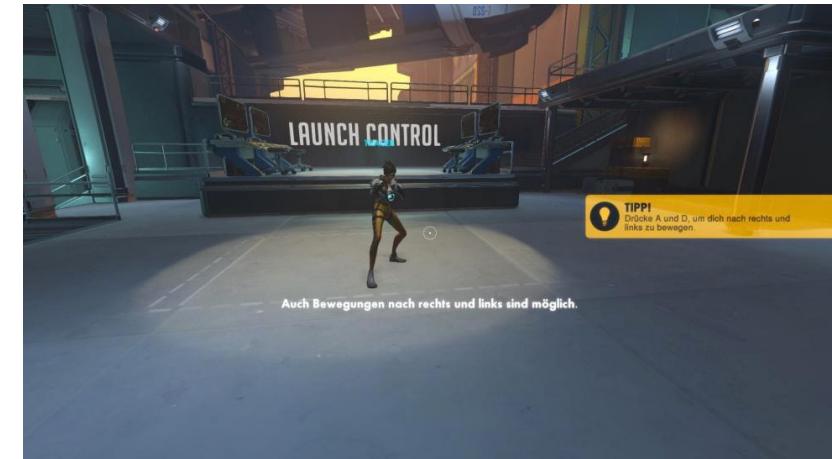
# AI as Role-model: Tutorials

Most frequent place you currently see this design pattern.

AI agent walks player through tutorial by showing the player how to act, or as a goal for the player to aspire to.



Mega Man X (1993)



Overwatch (2015)

# AI as Role-model Techniques

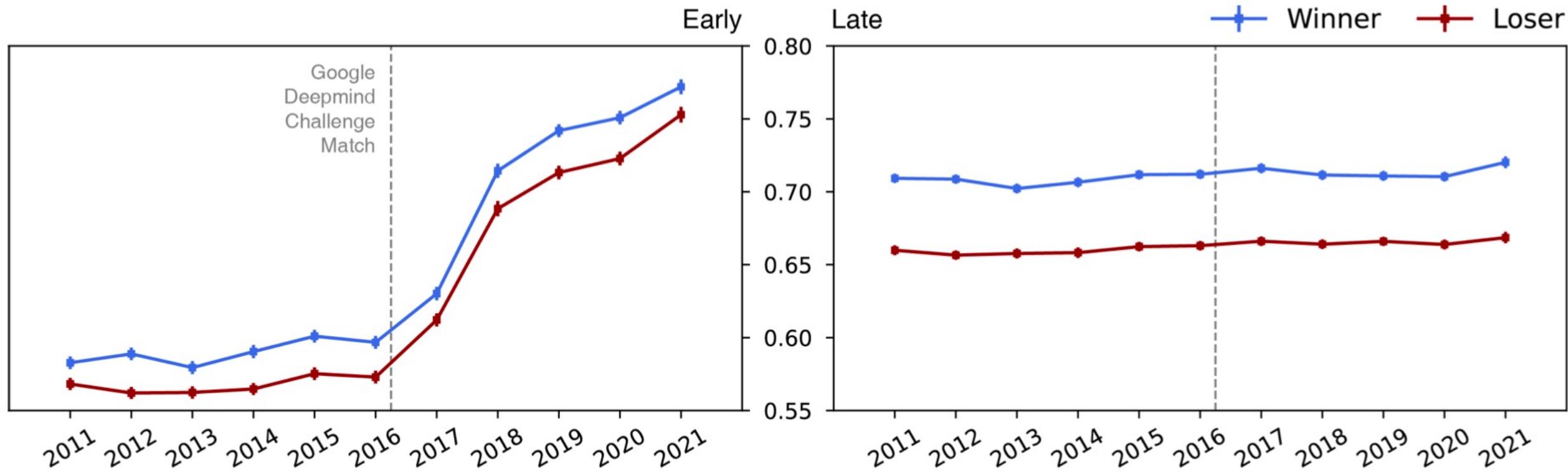
Typically done with “scripting” (preprogrammed sequence of states in a state machine). But could imagine any decision making technique

- FSM/Btree: Typical solution, gives designer the most direct control

But could we imagine using an “optimal” player like a Deep RL agent as your in-game instructor?

- Reinforcement Learning/Deep Neural Network: Train role-model beforehand so that it plays game perfectly.
- “Your buddy the Grandmaster”:  
<https://ojs.aaai.org/index.php/AIIDE/article/download/7402/7312>

# Deep RL “role-models” in games: Go



Extent to which professional South Korean Go players moves matched a Deep RL agent's in early and late game

# AI as Role-model: Player Experience

- Player Goals: Gives player an embodied entity/goal to match
- Roleplay: Partnered with design and narrative engages player in the world

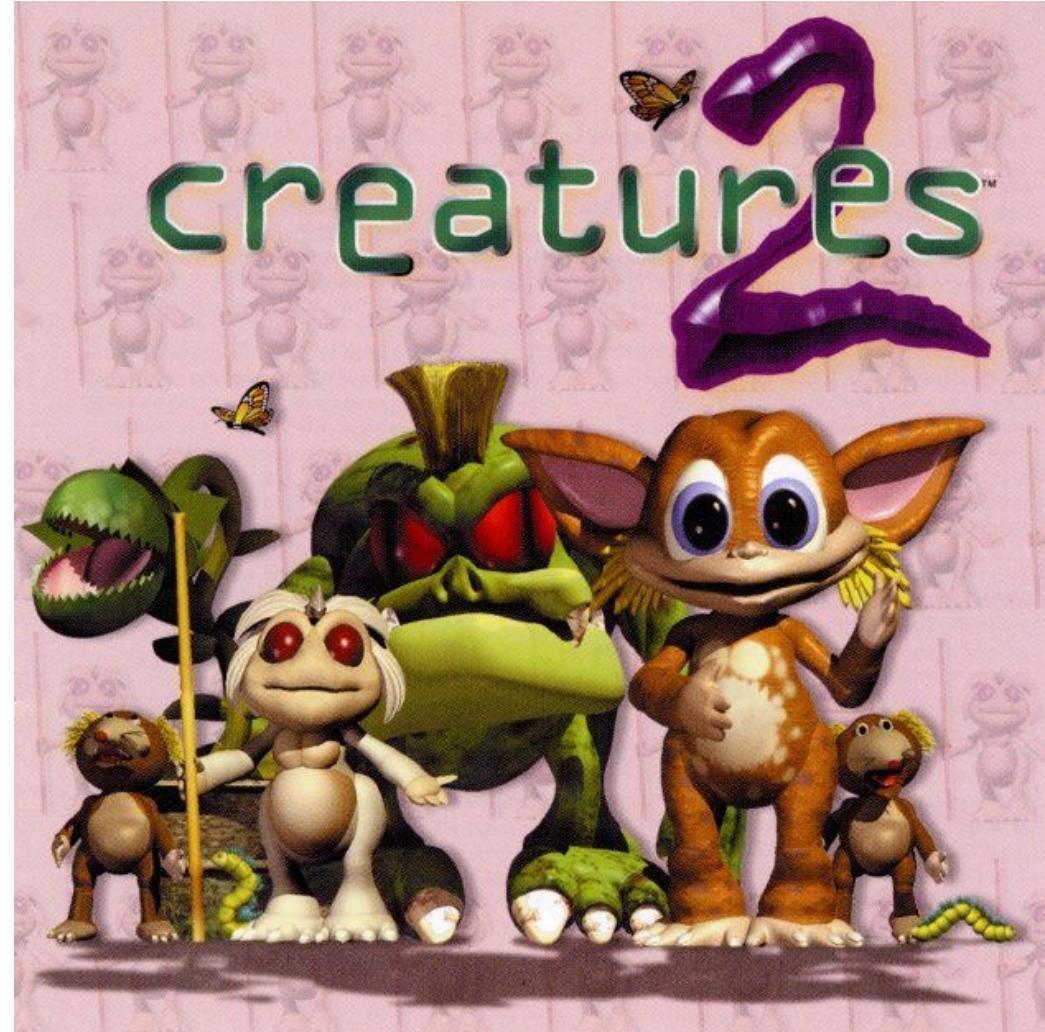


Skyward Sword (2011)



Final Fantasy X HD (2014)

AI as Trainee: Creatures (1996) and  
Creatures 2 (1998)



# AI as Trainee: Black & White 2 (2005)



[https://youtu.be/esM\\_t3mo\\_Lw?t=367](https://youtu.be/esM_t3mo_Lw?t=367) (Ignore Audio)

# AI as Trainee: Lab Assistant (2018)

## Natural Language Processing DNN



<https://lizfiacco.itch.io/lab-assistant>

# AI as Trainee: Aivolution (2019)



# AI as Trainee: My Dragon From Hell (2020)

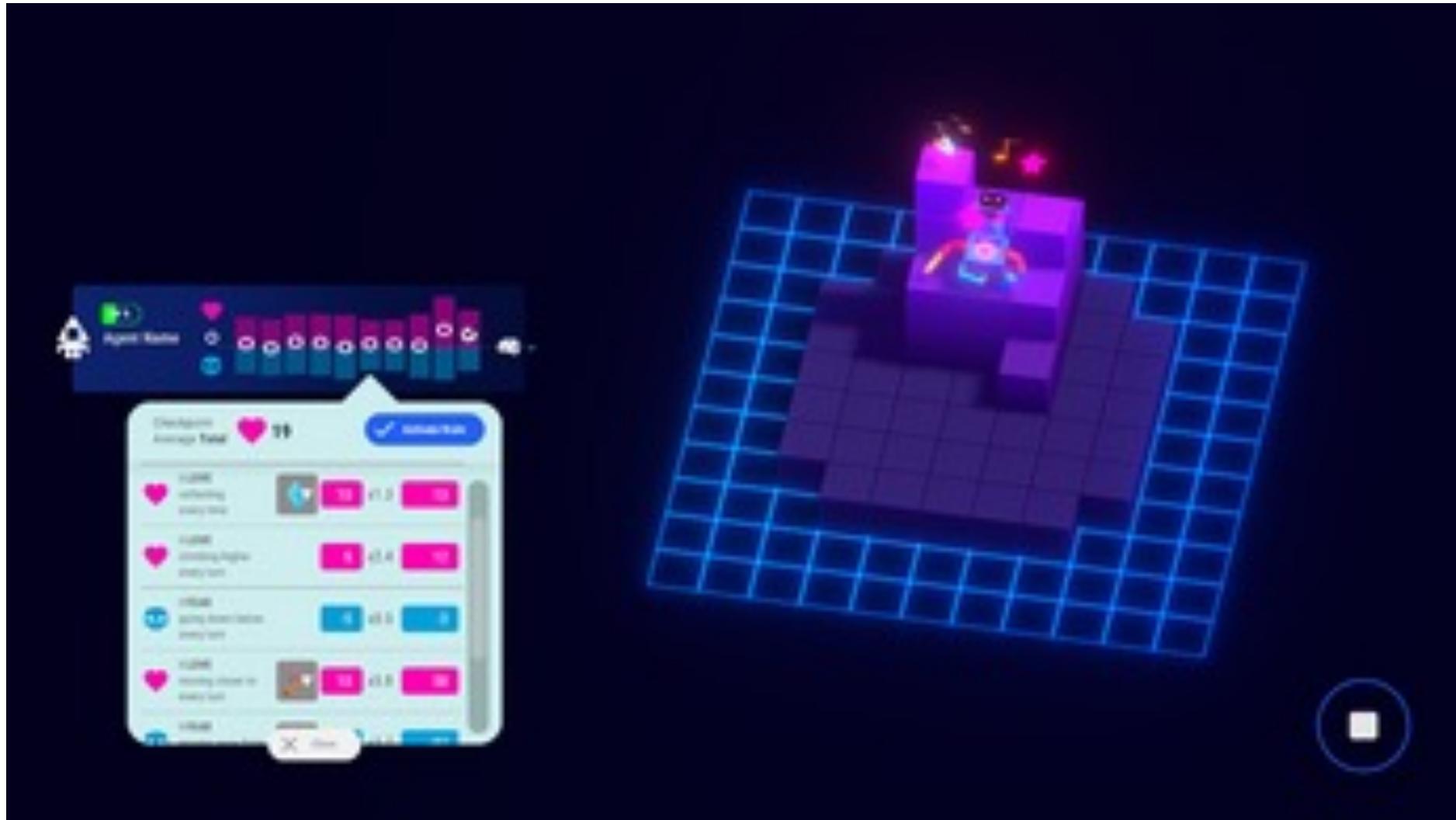
## Deep Q Learner



<https://lizfiacco.itch.io/my-dragon-from-hell>

<https://youtu.be/2hgOpVkfuf4>

# AI as Trainee: Amino (2021)



<https://transformsai.itch.io/animo-lab>

# AI as Trainee

- The exact opposite of the last pattern. An AI agent either learns explicitly or implicitly from the human player.
- Play arises from trying to impact what is learned to accomplish some goal

# AI as Trainee: Techniques

Deciding factor is that some form of learning must occur:

- Parameter setting: Rule-based system where player actions impact transition variables of FSM
- Decision Tree: As in B&W, take every player interaction as an example and learn a tree.
- Supervised or Reinforcement Learning: Take player interaction as correct answer or as reward/penalties



# AI as Trainee: Player Experience Problem

- Novelty: Frequently the primary selling point
- Player Goals: “What can I get it to learn?”
- AI as Trainee as a pattern can frustrate players more than entertain
  - Not meeting expectations: AI cannot learn like another human
  - Learning the “wrong” thing: AI can learn something the player didn’t intend

# AI is Editable: Dragon Age 2 (2011)



[https://youtu.be/t\\_n1RGmvZF4?t=18](https://youtu.be/t_n1RGmvZF4?t=18)

# AI is Editable

- Player directly alters parameters exposed by the designers
- Gameplay shaped by the player choices for these parameters
  - Editing the AI is typically not the game's focus



Minecraft  
<http://minecraft.gamepedia.com/Customized>



Galactic Arms Race

# AI is Editable

All of the techniques we discussed this semester have parameters that could be exposed for players to tune:

- Heuristic Values: For any of the techniques that use heuristics
- Rule-based systems: conditions/effects
- FSMs/Btrees: transition variables, states, nodes, etc.
- Planning: Conditions of actions
- Etc...

# AI is Editable: Player Experience

- Customization: Gives players a way to shape their experience directly, and to show off parameter sets
- Player Goals: Can introduce implicit player goals to min/max settings or to create a particular artifact or behavior

PQ1 <https://tinyurl.com/guz-pq34a>

<https://forms.gle/FjXJKcMh7tQ5ZC9n6>

AI is Editable and AI as Trainee involve directly and indirectly (respectively) altering AI parameters.

- A. In what kind of game (name one other than those I mentioned or invent one) would you want to use AI is Editable over AI as Trainee?
- B. In what kind of game (name one other than those I mentioned or invent one) would you want to use AI as Trainee over AI is Editable?

# Question 1: My Answer

AI is Editable: The design goals include a default artifact appearance or behavior, the ability to alter the parameters is meant for *depth*, but not an integral part of the base game.

AI as Trainee: The narrative and ludic (mechanical) design of the game call for a teacher-student or parent-child-like relationship

# AI is Guided: Lemmings (1991)



<https://www.youtube.com/watch?v=j9Je6pFueYg>

# AI is Guided: The Last Guardian (2016)



# AI is Guided: Airborne Kingdom (2020)



# AI is Guided

- Player does their best to guide AI agents to some goal state they wouldn't reach alone
- AI is Guided makes up the majority of gameplay
- Games that make use of this pattern referred to as “Sims” or “God-games”
  - Alternatively if just part of a game “escort missions”



The Sims (2000)



Sim Ant (1991)



Sim City (1989)

# AI is Guided: Techniques

Need some agents (typically embodied, but can be something more abstract like a city), which means any decision making approach

- FSM/Btree
- Rule-based system: Simulation -> Sim

What if instead we could have a player setting goals for a trained Deep RL agent?

Or goals for a planning agent?



Ico (2001)

# AI is Guided: Player Experience

- Player Goals: Anyone who has tried to drown a Sim knows about emergent implicit goals that arise from these systems
- Power Fantasy: The player literally acts as a god, with all the power the game allows

# Quick Reminder...

Over halfway through. Remember multiple patterns in a single game.

## The Sims

- AI is Editable (recreate friends/fictional characters)
- AI is Guided (keep the Sims alive or the opposite)
- AI is Visualized (see internal state)
- AI is Co-creator (create narratives with the AI)
- AI as Spectacle (watch the AI and see what happens)

# AI as Co-creator: LuminAI (2017)



<https://www.youtube.com/watch?v= 3s7nC0E5n4>

# AI as Co-creator: AI Dungeon 2 (2019)

You are Stephen, a survivor trying to survive in a post apocalyptic world by scavenging among the ruins of what is left. You have a hatchet and a hunting rifle. You live in a small community of survivors who have managed to build a piece of civilization after the bombs fell. You are talking to one of the leaders of the community when you realize that this man has been watching you for some time now. He knows your name and he knows where you live.

> Ask "What do you want with me? Why have you been watching me?"

The leader looks at you as if he wants to say something but then decides against it. "I don't know what you mean by that," he says. "We all know you're not human."

> Say "But I am human, what are you talking about?"

# AI as Co-creator: Elsinore (2019)



# AI as Co-creator: Umurangi Generation (2020)



# AI as Co-creator: New Pokémon Snap (2021)



<https://www.wired.com/review/new-pokemon-snap-review/>

# AI as Co-creator

- AI agent(s) and the human player work together to produce an artifact, narrative, or experience
- Related to Co-creative or Mixed-initiative Design

# AI is Co-creator: Techniques

Many options:

- If the AI co-creator is an embodied agent partner, need any decision making approach (FSMs, BTrees, planning, etc.)
- If the AI co-creator is acting as a student, need a machine learning decision making approach (Decision trees, RL, etc.)
- If the AI co-creator is acting as a judge or critic, make use of a heuristic or fitness function.
- Etc.

# AI is Co-creator: Player Experience

- Player Goals: What can I make?
- Sharing Content: Sharing the stories, experiences, images that you produce with friends

# AI as Adversary: Super Smash Bros. (1999)

## CPU Players



# AI as Adversary: Bloodborne (2015): Other Hunters



# Fortnite (2017): AI Players



# AI as Adversary

- Symmetric relationship in ability between players and AI with an adversarial relationship
- Gameplay arises from the challenge of attempting to beat the enemy AI
- Typical Techniques: These are the techniques we've focused on all semester.
- But what if your adversaries adapted to you over a game? Or actually had more complex decision making (like you do)?



Soulcalibur VI

# AI as Villain: Alien: Isolation (2014)



<https://www.youtube.com/watch?v=4X-ITXZZ6-s>

# AI as Villain: Middle-earth: Shadow of Mordor (2014): Nemesis System



# AI as Villain: Resident Evil Village (2021): Lady Dimitrescu



# AI as Villain

- Asymmetrical antagonistic relationship between player and AI.
- Gameplay effect same as antagonistic, but villain more of a focus.
- Typical Techniques: Decision Making (same as Adversary)
- But what if... An AI villain learned and adapted to you (for real)?



Untitled Goose Game (2019)

# AI as Spectacle: Everything



<https://www.youtube.com/watch?v=JYHp8LwBUzo>

# AI as Spectacle: OpenAI Five in DOTA



# AI as Spectacle

- The original authors (Mike and the gang) couldn't think of a single specific example of this one.
- Basically, anytime you'd just want to sit back and watch the AI "go" rather than play the game.
- Techniques: ?

# Way to think about these patterns

How common is the pattern in games?

1. Adversary, Guided, and Visualized
2. Villain, Editable, and Trainee
3. Co-creator
4. Spectacle

Note this ranking is not absolute or objective, and only exists to give a general sense of relationships between patterns

# Another way to think about these patterns

How integral is this design pattern to the overall game design?

1. Guided, Co-creator, Villain, Adversary, and Spectacle
  - Game could not exist without it
2. Visualized, Role-model, Trainee
  - Game could continue in some form without it
3. Editable
  - Many players will never see

# Using the Patterns

Prescriptive: What happens if we use patterns (A,B,C) and AI techniques (X,Y,Z)?

- What kind of game do we get?

Descriptive: As a common language to talk about different game designs and their commonalities

- Ex. What do the Sims and Resident Evil 2 have in common?

## PQ2 (time-permitting)

<https://tinyurl.com/guz-pq34b>

<https://forms.gle/kJVakj7KH5yPPwPXA>

Pick 2-3 patterns and 1-2 AI techniques and give me a high-level concept for a single game:

1. AI is Visualized: Observe/React to AI State
2. AI as Role-model: Imitate/Learn from AI
3. AI as Trainee: Teach the AI
4. AI is Editable: Edit the AI
5. AI is Guided: Guide/manage the AI
6. AI as Co-creator: Make artifacts assisted by AI
7. AI as Adversary: Typical enemy AI role
8. AI as Villain: Adversary but with *drama*
9. AI as Spectacle: Observe the AI

## Question 2: My Answer

Many years ago, Alex Zook (the Unity guy) and I made a prototype for a game about creating your own ecosystem, the goal would be for the player to indirectly (**AI as Trainee**) and directly (**AI is Editable**) alter species in their ecosystem.

Members of a species would run on a unique **Finite State Machine**, and the whole thing would run on a **Genetic Algorithm** where the Genetic Algorithm optimized both physical characteristics of a species and the FSM itself (changing both appearance and behavior over time).

Thank you... and please do your USRIs!

# Quiz 6 Review

- **Topics to be able to “run”:** RL in Games (Epsilon Greedy, Q-learning intuition, Deep Q-learning intuition), Automated Game Playing (History, Belief), Dialogue and Narrative Generation (Grammars, Rules, Neural Nets intuition, Neurosymbolic intuition), and the patterns from today.
- **Topics to remember:** Spatial Representations, Path planning, Decision Making, and Player Modelling

# More AI Games I didn't mention

- <https://keiwan.itch.io/evolution>
- <https://store.steampowered.com/app/833400/Corral/>
- <https://buddhaman.itch.io/football-evo>
- <https://www.kickstarter.com/projects/924858949/hey-robot>
- <https://quickdraw.withgoogle.com>