In The Name Of God

Game AI Research: A Gentle Introduction

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Agenda

- Warm-up
  - A little about me
  - Theme of the talk
- Why game AI research?
- AI for playing games
- Procedural content generation
- Player modeling
- How/where to begin?

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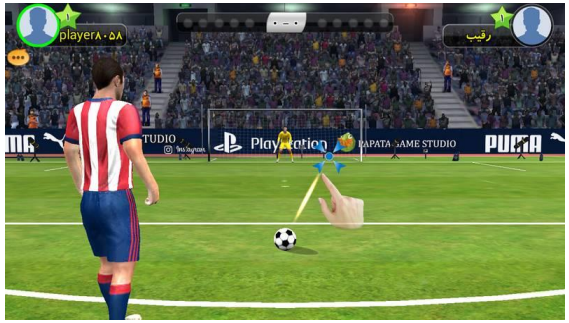
Who Am I?

- Academia
  - 2007-2011: B.Sc. in Software Engineering, University of Kashan, Iran
  - 2011-2013: M.Sc. in AI, Sharif University of Technology, Iran
  - 2013-2017: Ph.D. in AI, Isfahan University of Technology, Iran (Dropped Out)
  - 2017-Present: Ph.D. in Computer and Video Games, Aalto University, Finland

- Industry
  - 2011-2012: E.T. Armies (AI Programmer)
  - 2012-2013: Awakening: Burning Ashes (Lead Programmer)
  - 2016-2017: Cut (Gameplay and AI Programmer)



Theme of the Talk

- From theory to practice…

Theme of the Talk

- From theory to practice…

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Games as Testbeds for AI

John McCarthy playing chess against computer, 1966

Deep Blue

Deep Blue defeated Gary Kasparov, 1997

AlphaGo

AlphaGo defeated Lee Sedol, 2016

Games Are Rich

- Planning
- Adversarial search
- Navigation
- Machine learning
- Data Mining
- Natural language processing
- Signal processing
- Artificial Creativity
- Artificial Psychology

Games Are Fun

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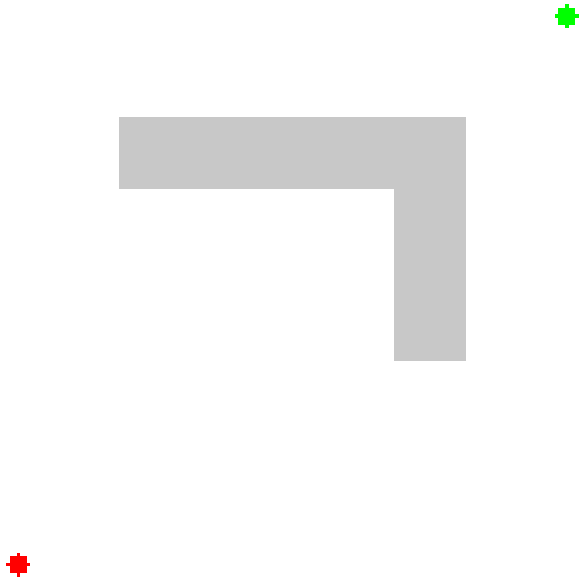
Motivations

- As a player
  - Testbeds for AI algorithms
  - Gameplay testing
  - Game balancing
- As a non-player
  - Non-playable characters
  - Human-like agents
  - Game balancing

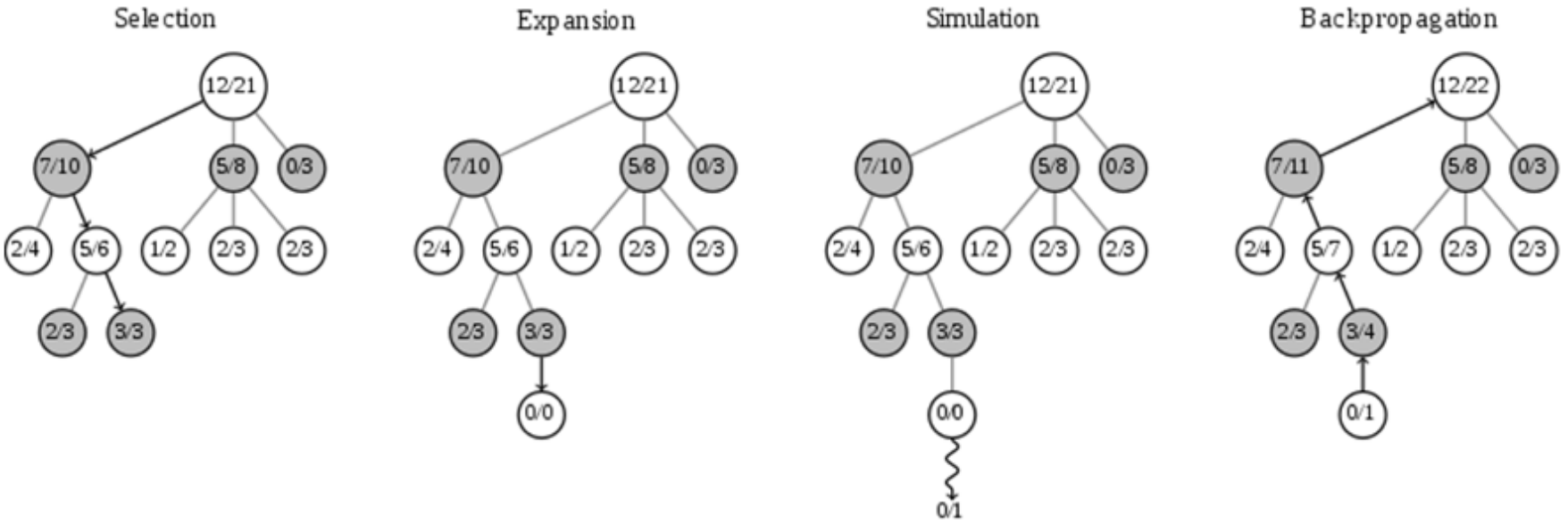
Approaches

- Planning-based approaches
  - A*
  - MCTS
  - Evolutionary planning
- Reinforcement learning
  - Classic RL
  - Deep RL
  - Evolutionary RL
- Supervised learning
  - Imitation learning

A*

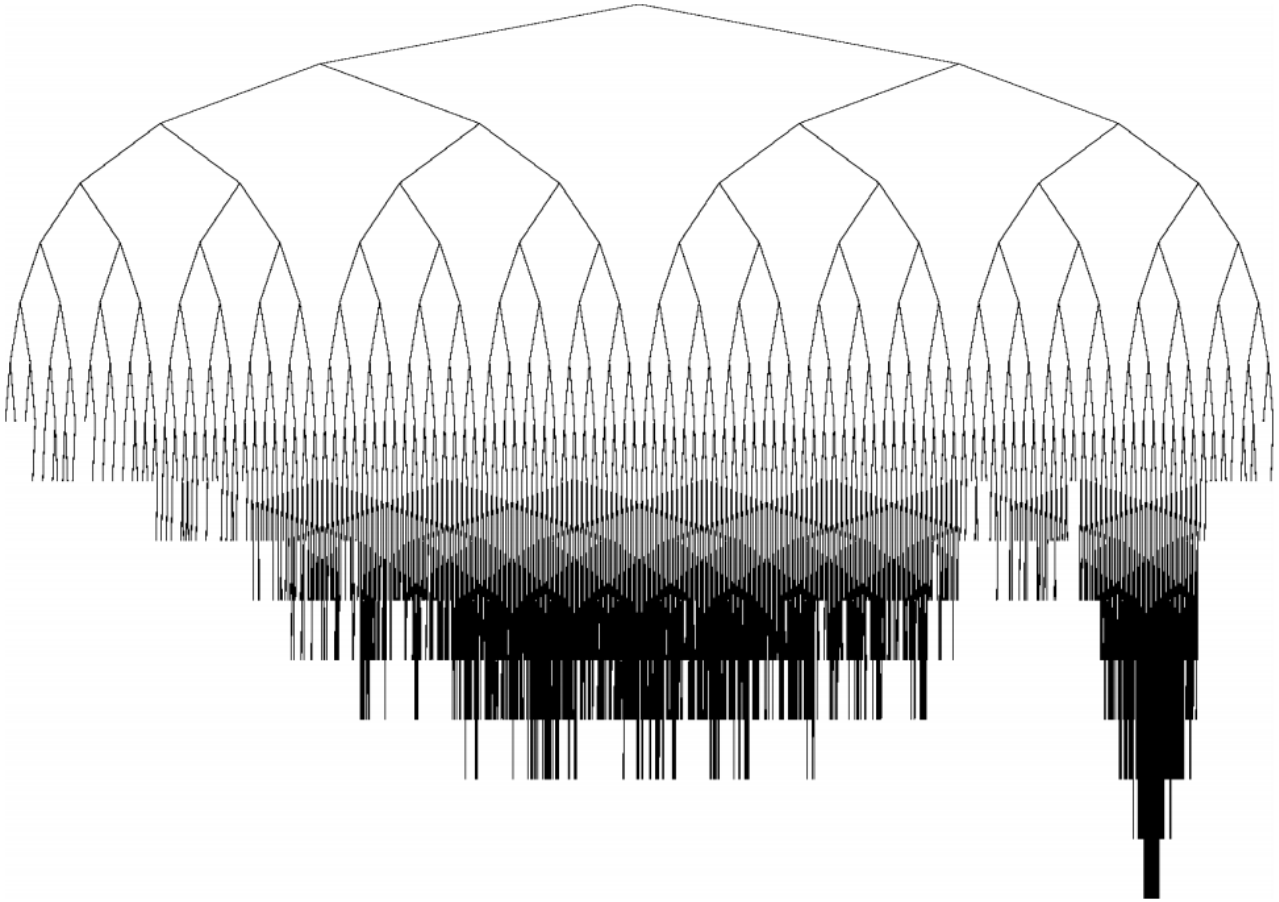


Monte Carlo Tree Search (MCTS)

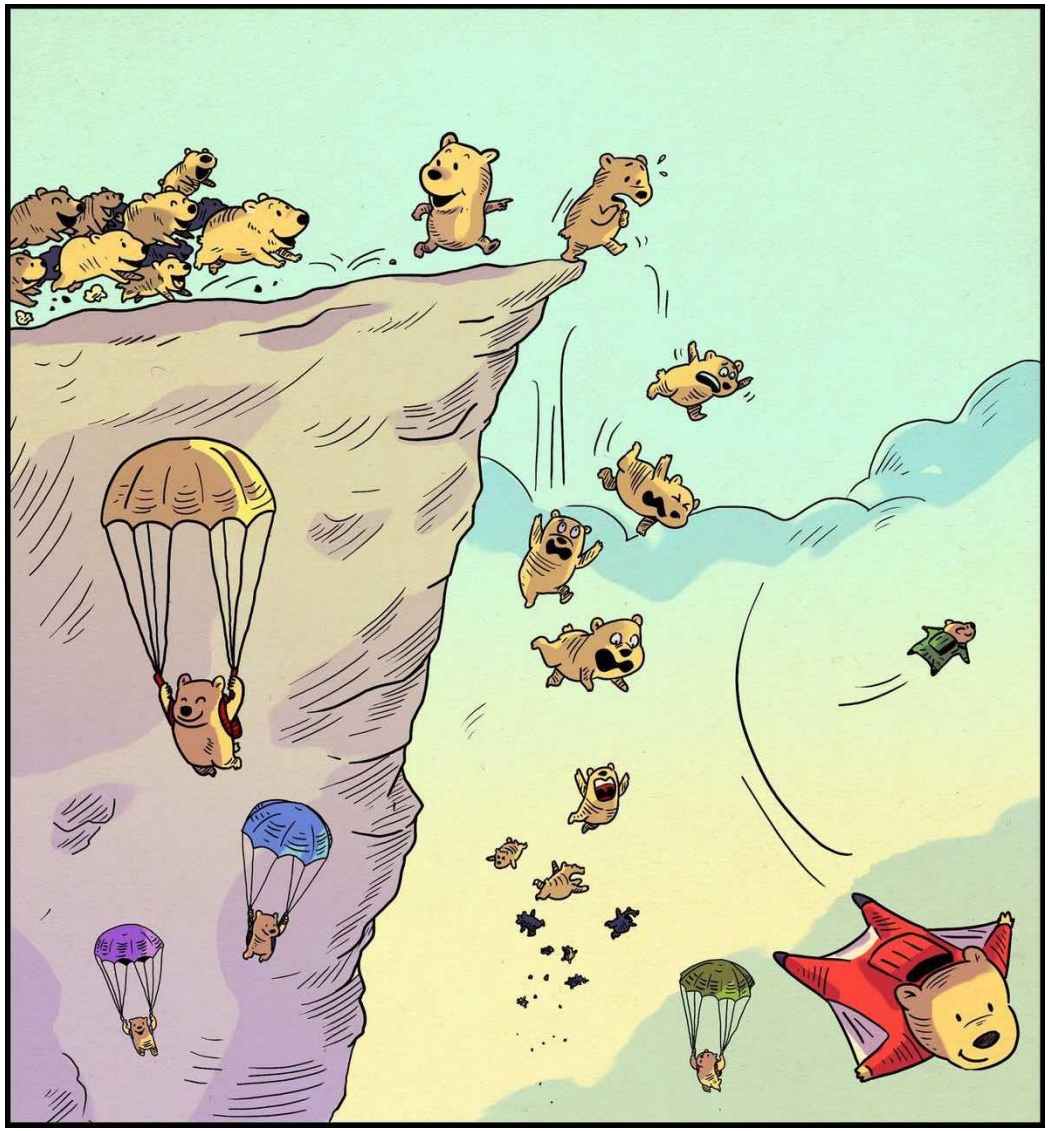


MCTS Characteristics

- Aheuristic
- Anytime
- Asymmetric

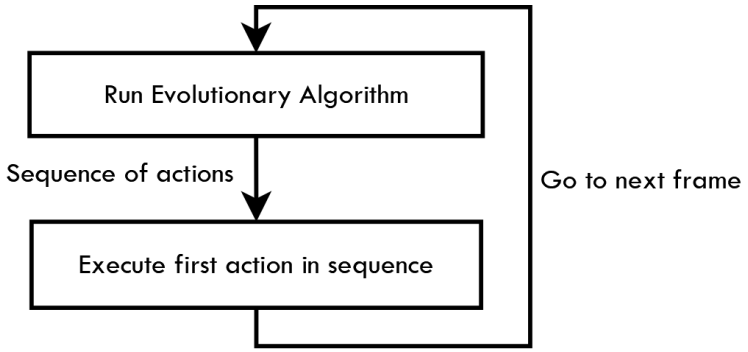


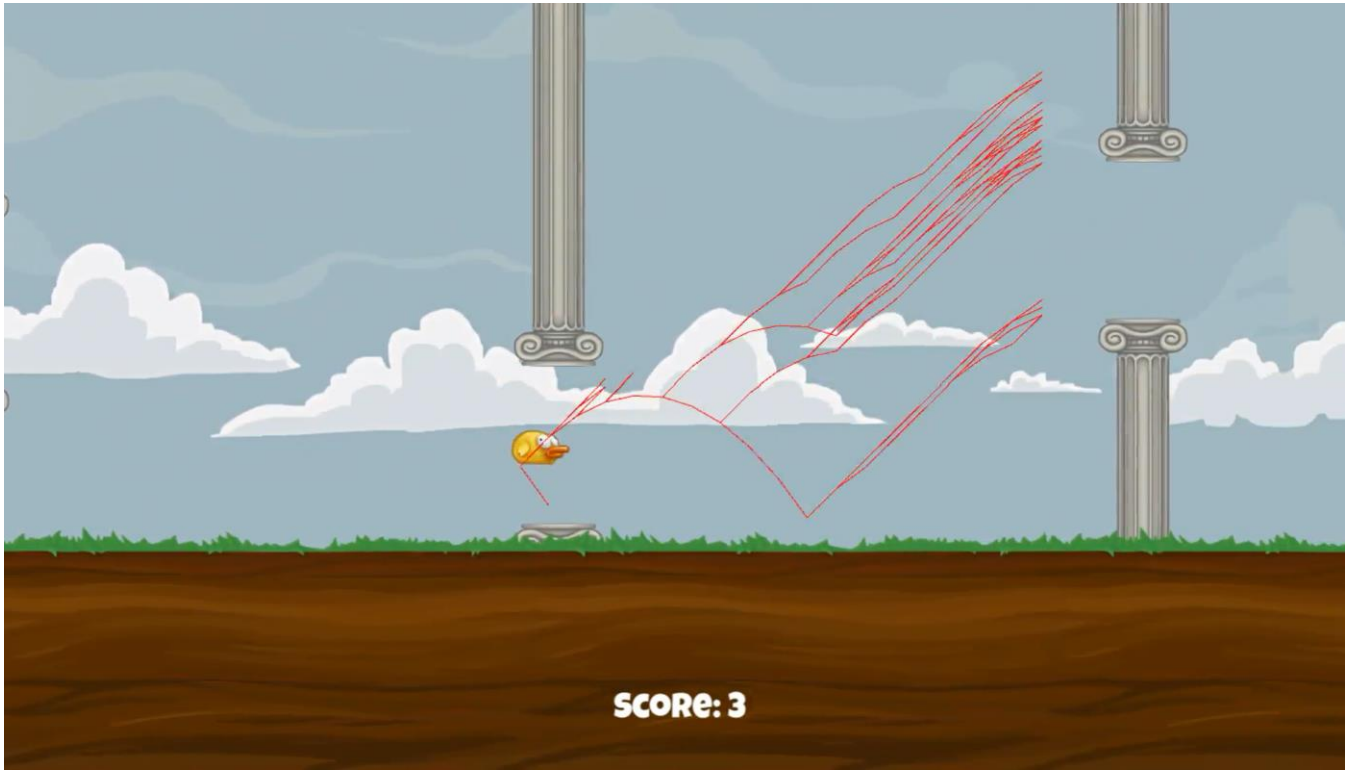
Evolutionary Planning



Rolling (Receding) Horizon Evolution

- Genetic algorithm (for discrete actions)
- Evolution strategy (for continuous actions)





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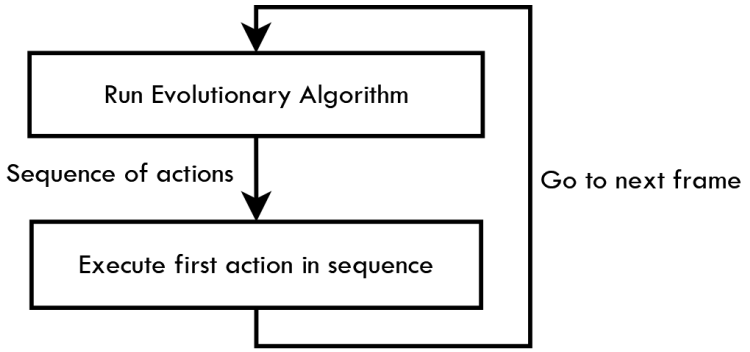
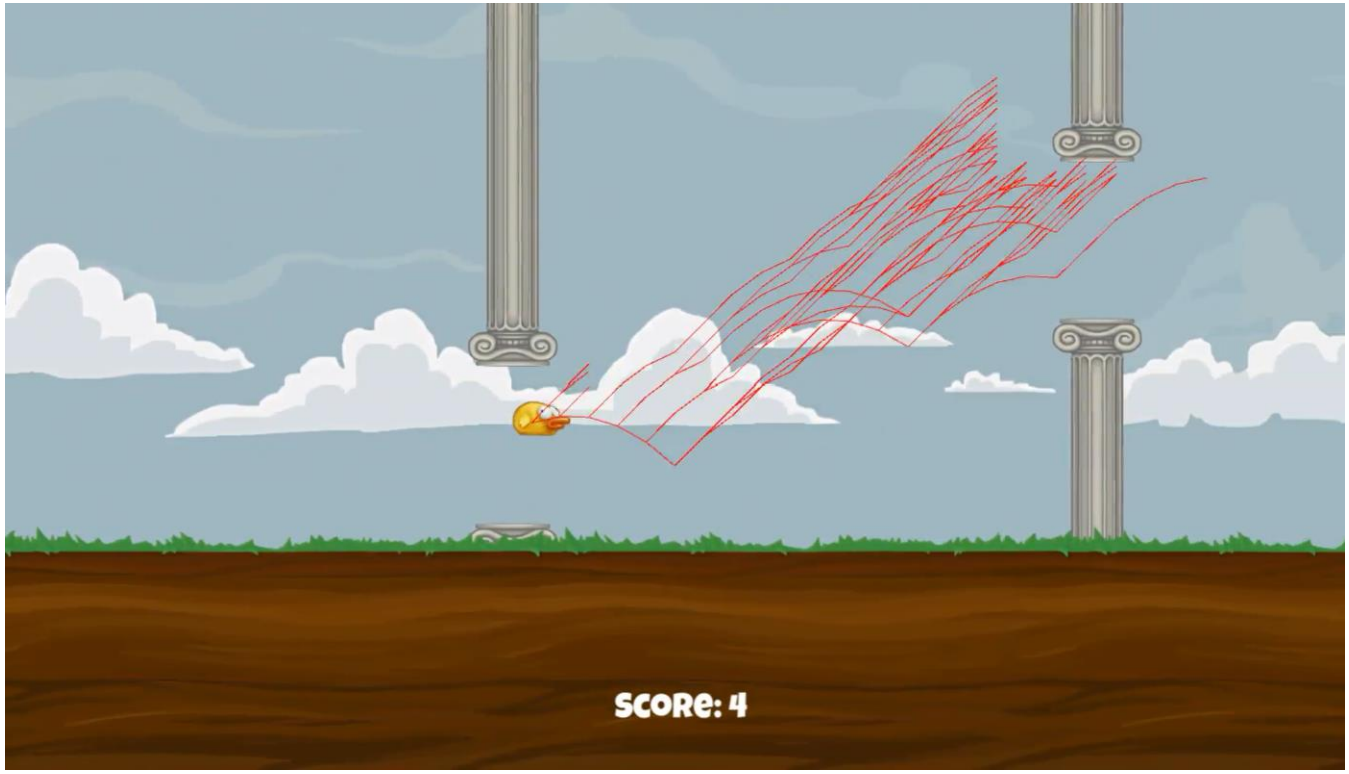
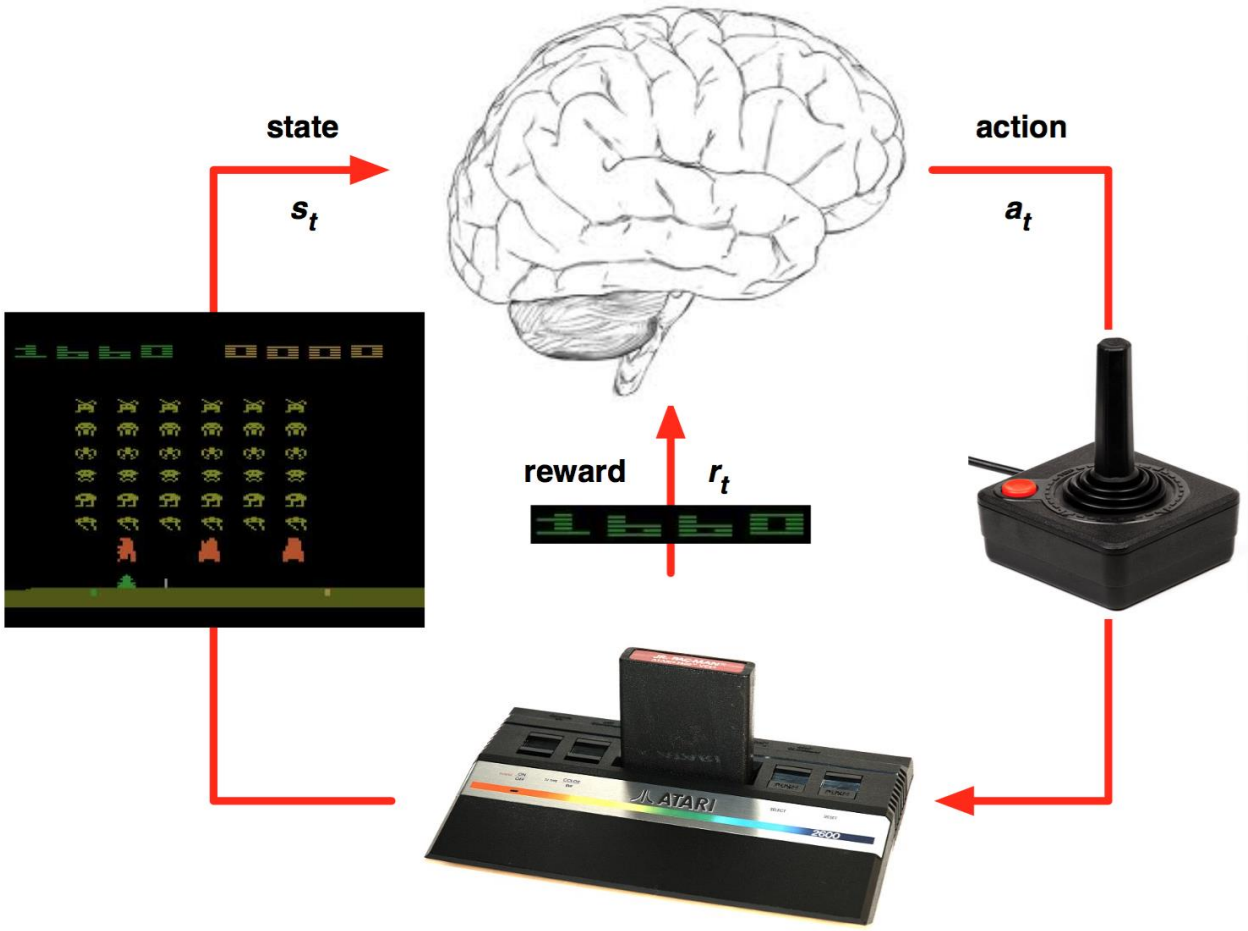


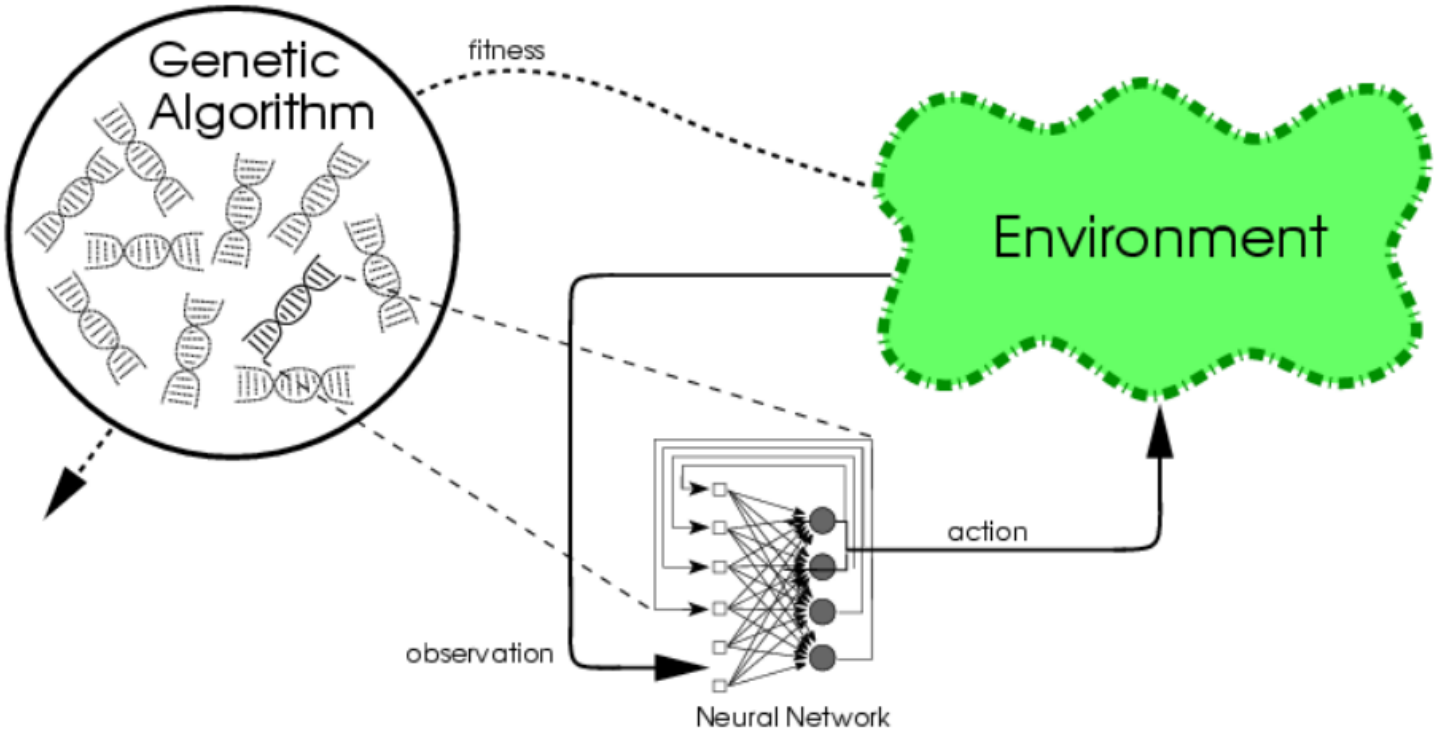


Classic/Deep Reinforcement Learning



Evolutionary Reinforcement Learning

- Also known as Neuroevolution



Imitation Learning

x_i	$\Rightarrow$	y_i
	$\Rightarrow$	JUMP
	$\Rightarrow$	DOWN
	$\Rightarrow$	RIGHT
$\vdots$		

$\Rightarrow$?

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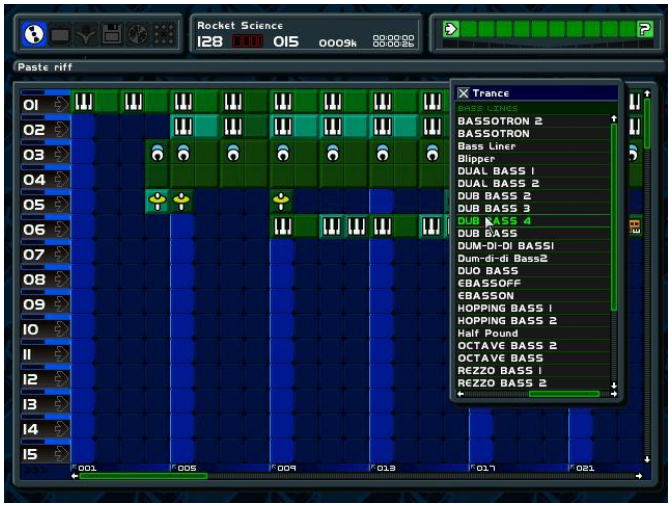
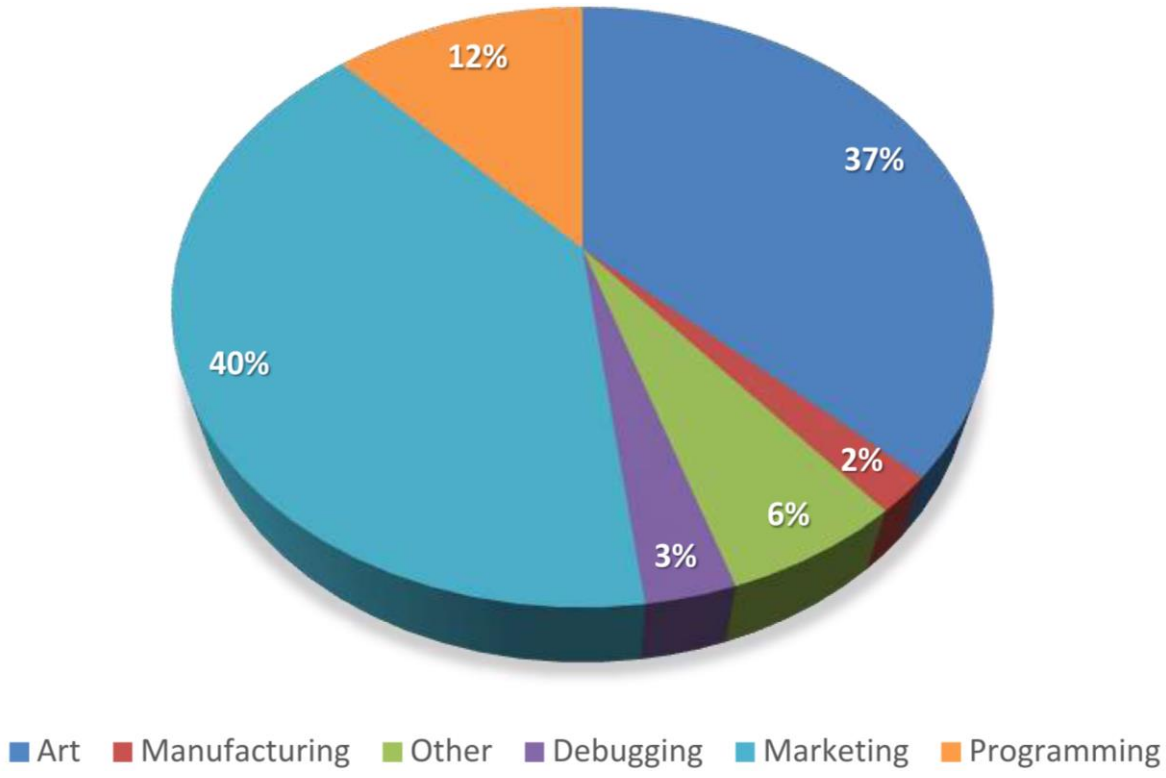
What Is Content?

- Models (characters, vehicles, weapons, etc.)
- Textures
- Animations
- Levels
- Maps
- Music
- Game rules
- Stories
- Dialogs
- Items
- Quests
- …



Motivations

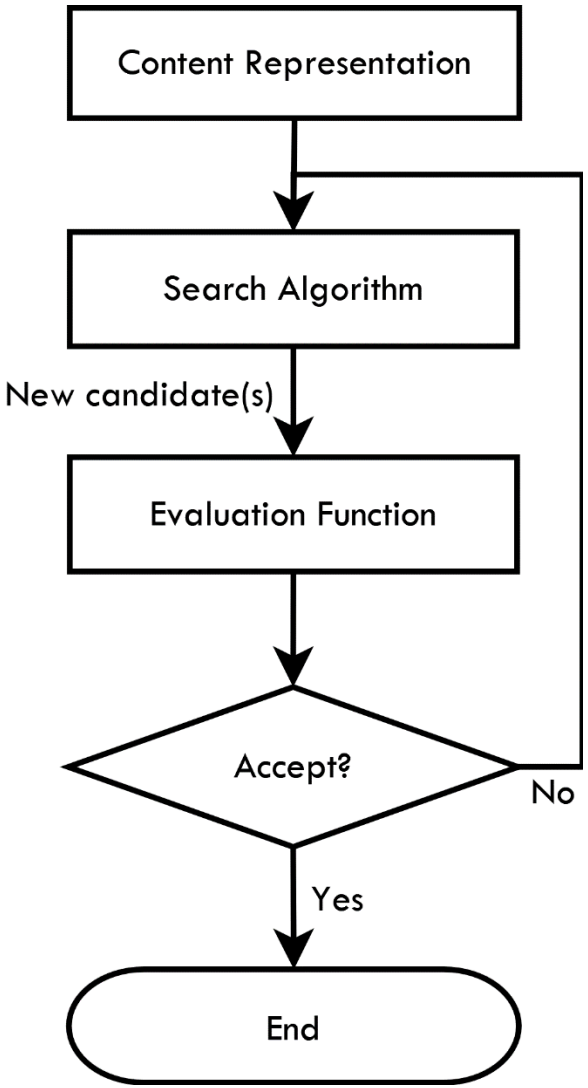
- Faster development
- More creativity
- Player-adaptive games
- Cheaper development



Approaches

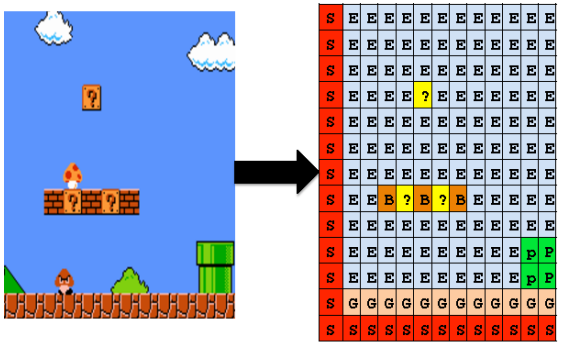
- Search-based methods
- Solver-based methods
- Grammar-based methods
- Machine learning
- Cellular automata
- Noise and fractals

Search-Based Methods

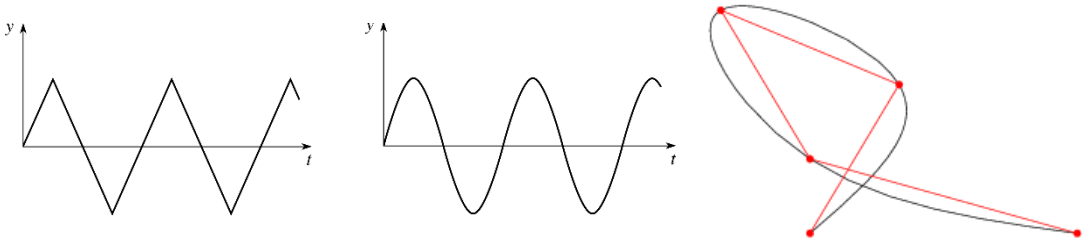


Content Representation

- Could be anything depending on the "content"
  - Maps/levels/Textures

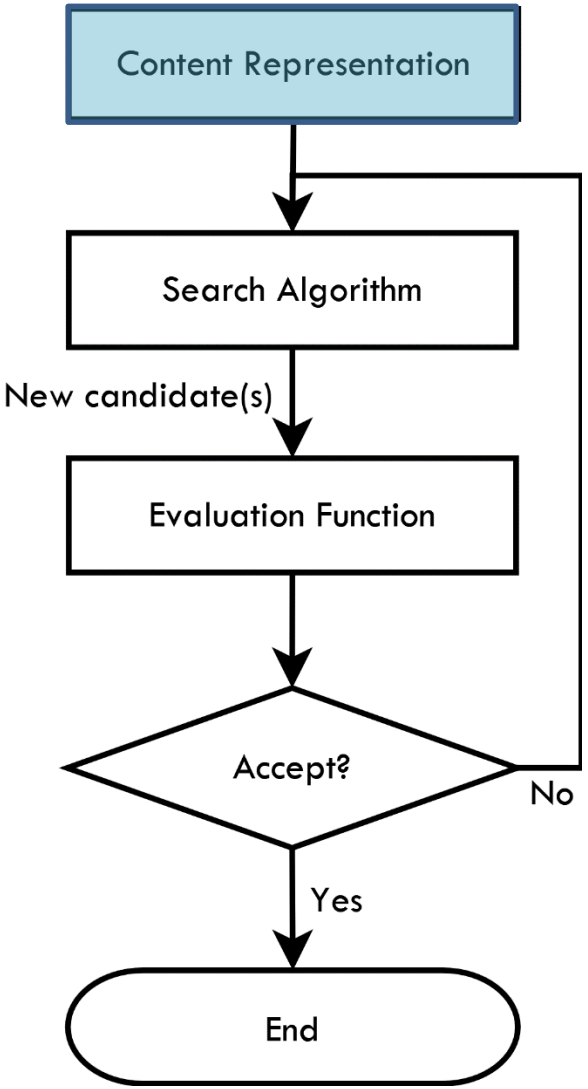


  - Animations/Music



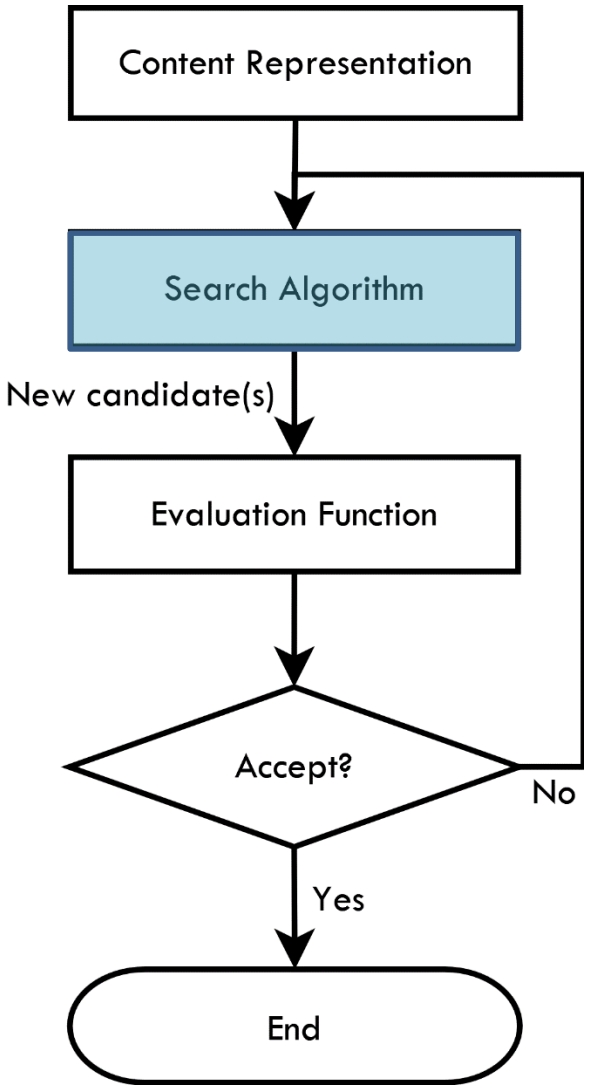
  - Stories/Dialogs

I	1	0	0	0	0
love	0	1	0	0	0
cake	0	0	1	0	0
hate	0	0	0	1	0
pizza	0	0	0	0	1



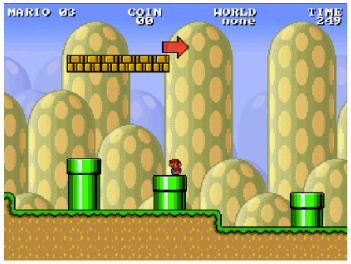
Search Algorithm

- Evolutionary algorithms
  - Genetic algorithm
  - Genetic programming
  - Evolution strategy
- Search algorithms
  - A*

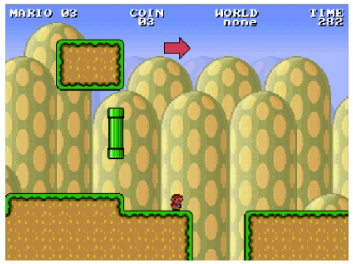


Evaluation Function

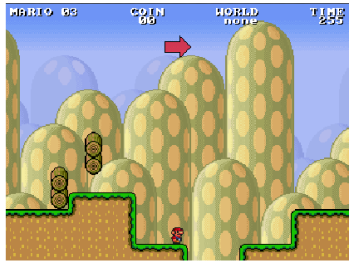
- Direct
- Simulation-based
- Interactive



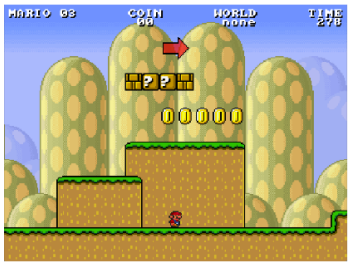
(a) (1, 1, 1)



(b) (2, 1, 3)



(c) (2, 3, 1)

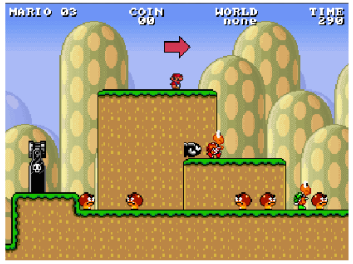


(d) (2, 4, 1)

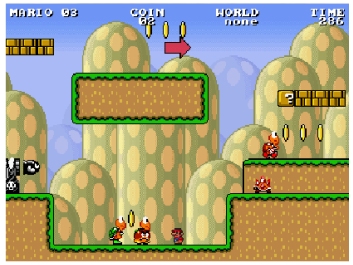
(e) (4, 7, 9)

(f) (6, 7, 5)

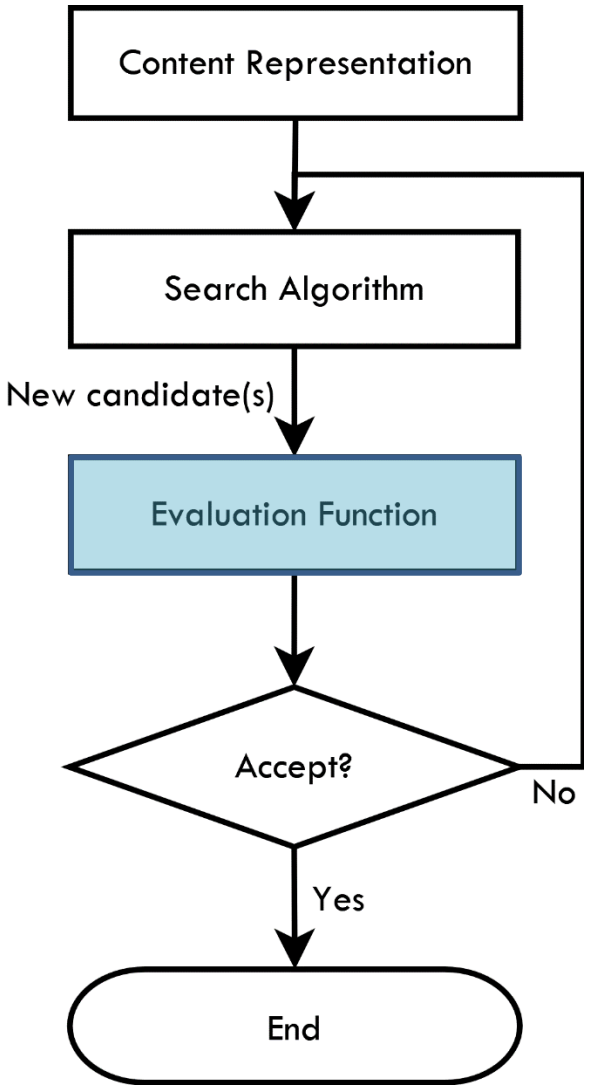
(g) (9, 9, 6)



(h) (4, 5, 3)



(i) (7, 7, 6)



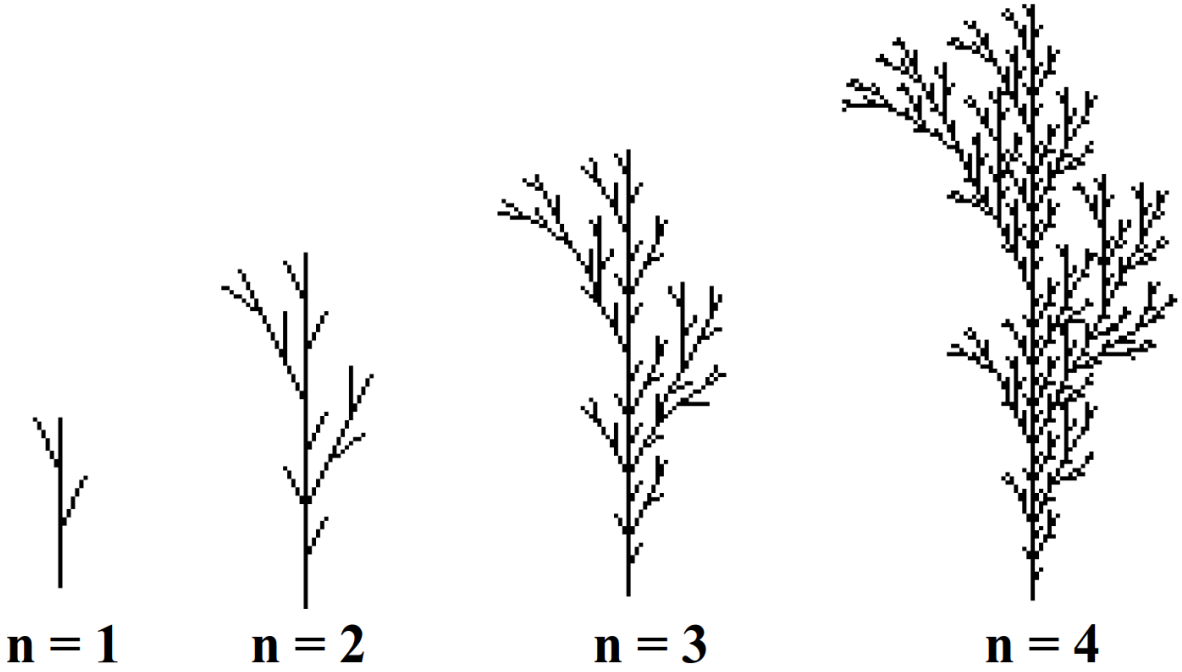
Solver-Based Methods

- Use constraint solvers
  - Satisfiability (SAT)
  - Answer Set Programming (ASP)
- Usually not anytime

Grammar-Based Methods

$$F \rightarrow F[-F]F[+F][F]$$

- F: move forward a certain distance (e.g., 10 pixels).
- +: turn left 30 degrees.
- −: turn right 30 degrees.
- [: push the current position and orientation onto the stack.
-]: pop the position and orientation off the stack.

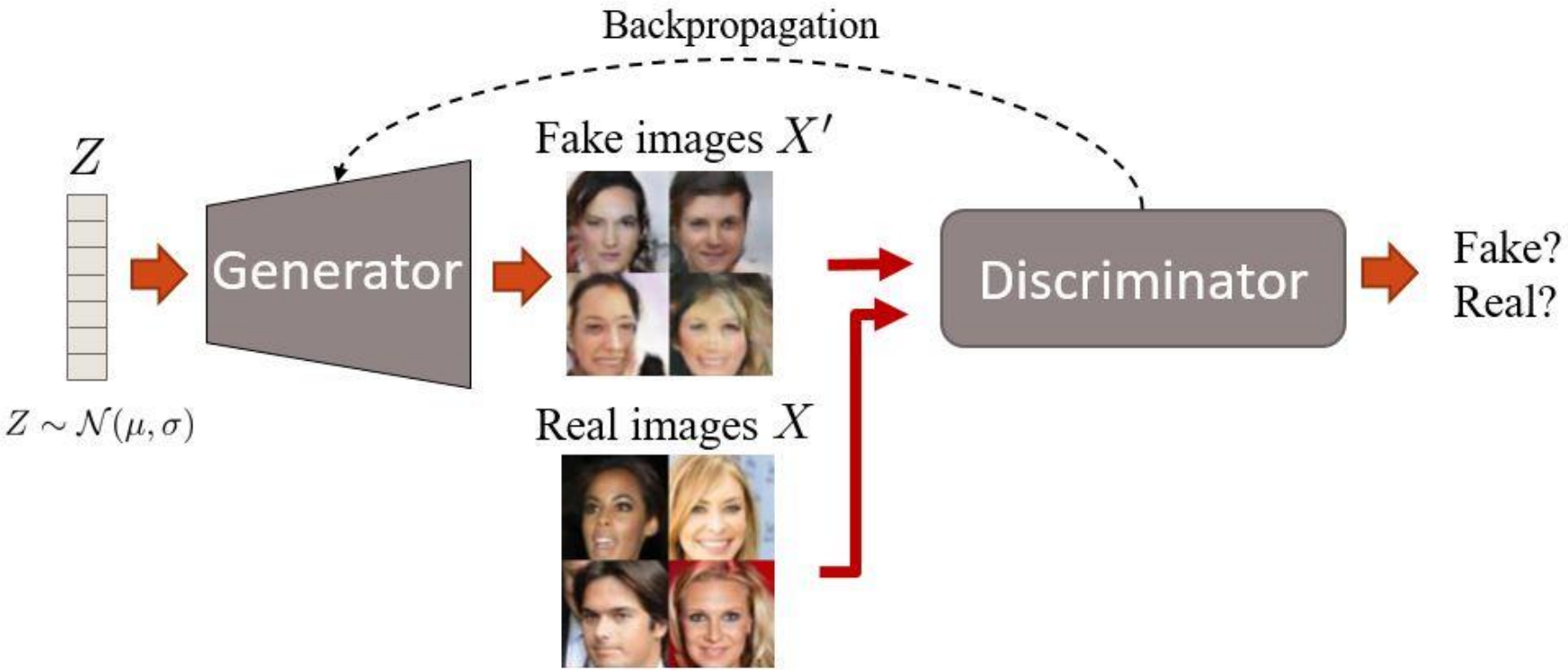


Machine Learning

- Mostly suitable for generating textures, models, text, …

- Approaches:
  - Generative Adversarial Network (GAN)
  - Variational Autoencoder (VAE)
  - Recurrent neural network (RNN)

Generative Adversarial Network (GAN)



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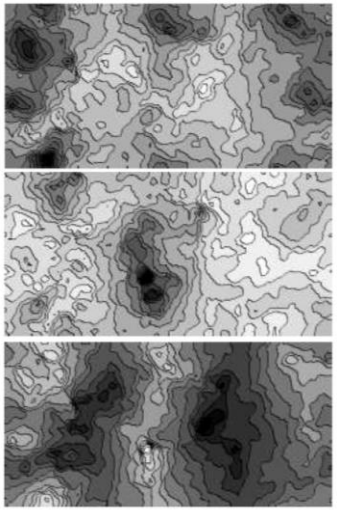
What Is Player Modeling?



Cause of Death: Opponent

Cause of Death: Environment

Cause of Death: Falling

Motivations

A High-Level Taxonomy of Approaches

- Model-based (top-down)
- Model-free (bottom-up, data-driven)

Approaches

- Supervised learning
- Unsupervised learning
- Reinforcement learning

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How/Where to Begin?

- Conferences
  - IEEE Conference on Computational Intelligence and Games (IEEE CIG)
  - Artificial Intelligence in Digital Entertainment (AIIDE)
  - Foundations of Digital Games (FDG)
  - ACM SIGGRAPH
  - CHI Play
- Journals
  - IEEE Transactions on Games (TOG)
    - IEEE Transactions on Computational Intelligence and AI in Games (TCAIG)
- Books
  - Artificial Intelligence and Games (http://gameaibook.org/)
  - Procedural Content Generation in Games (http://pcgbook.com/)
- Universities/Institutions
  - Ranking of institutions in technical games research (http://www.kmjn.org/game-rankings/)

Thanks!