

# Artificial Intelligence and Games

## Introduction



# Why a course on AI *in* and *for* Games?

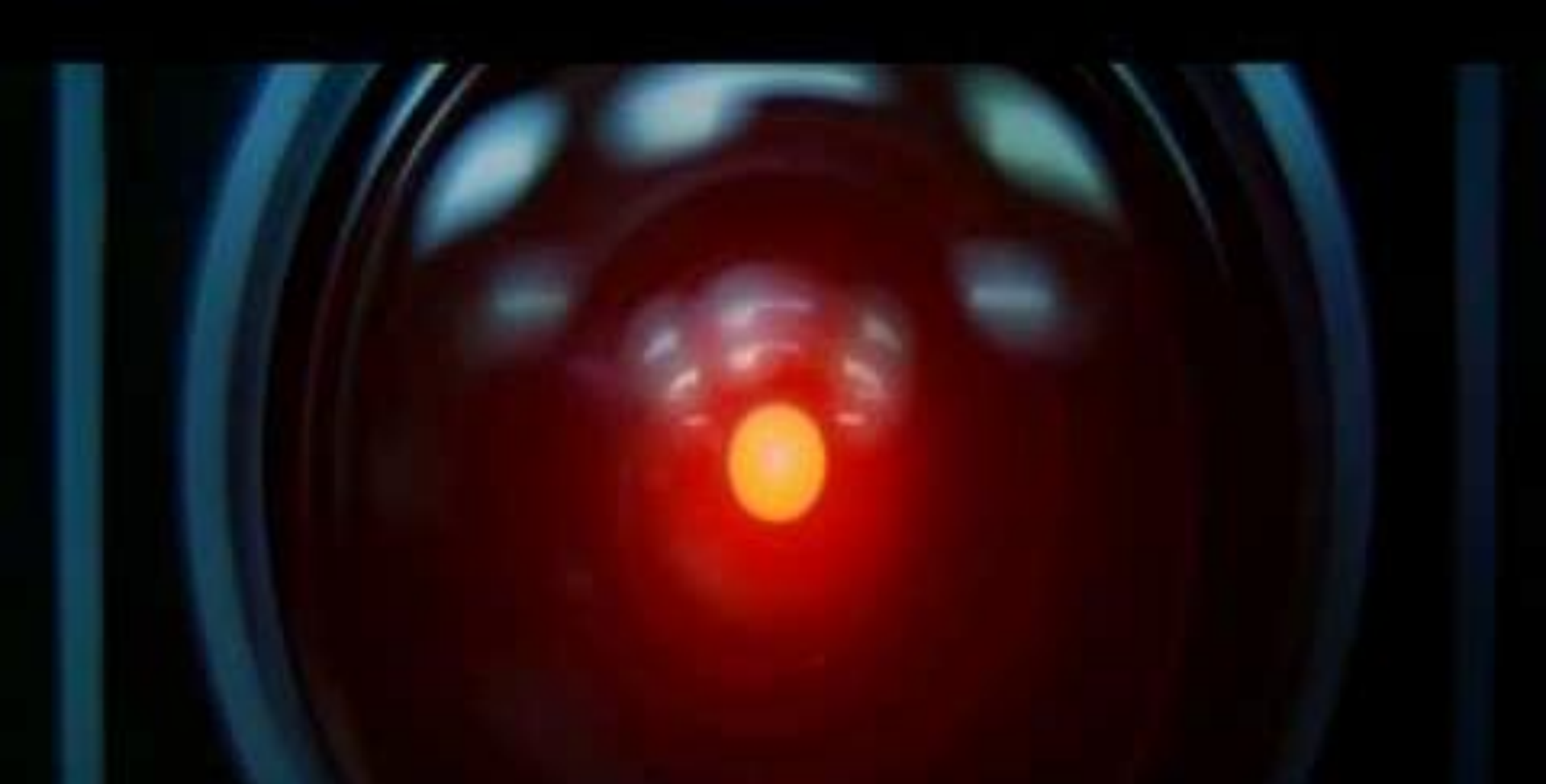


Artificial Intelligence is at the very core of modern game design and development. It plays and tests games, it supports their design, and it analyses the way we play them. AI techniques used for these tasks include **expert domain-knowledge systems, search and optimization, and machine learning**. This course aims to introduce students to the theory and practice of **game artificial intelligence**.

# Learning Objectives



- Describe and theorize on the AI algorithms covered in class.
- Identify tasks that can be tackled through AI techniques and select the appropriate technique for the problem under investigation.
- Compare the performance of different AI techniques and reflect on their suitability for game AI development.
- Design and implement efficient and robust game AI algorithms.



# Artificial Intelligence



# Artificial Intelligence



Making **computers** able to do things which currently only **humans** can do

# Artificial Intelligence in Games



Making **computers** able to do things which currently only **humans** can do **in games**

# What do Humans Do with Games?



- Play them
- Study them
- Build content for them
  - levels, maps, art, characters, missions...
- Design and develop them
- Do marketing
- Make a statement
- Make money!



# Games **for** Artificial Intelligence



# Games are Hard and Interesting Problems!



Calm



Stressed



Richest (?) HCI



NEVERMIND

BIOFEEDBACK IN ACTION

# Games are everywhere

## More Content More Data



# Games are content-intensive



# Games and AI Areas



Perception

Signal Processing

Machine Learning

Artificial Psychology

Planning and Search

KR and Reasoning

Natural language processing

Navigation

...

## ARTICLE PREVIEW

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NATURE | LETTER

日本語要約



# Google DeepMind

## Human-level control through deep reinforcement learning

Volodymyr Mnih, Koray Kavukcuoglu, David Silver, Andrei A. Rusu, Joel Veness, Marc G. Bellemare, Alex Graves, Martin Riedmiller, Andreas K. Fidjeland, Georg Ostrovski, Stig Petersen, Charles Beattie, Amir Sadik, Ioannis Antonoglou, Helen King, Dharshan



Figure 14236

Published online 25 February 2015

Key metrics

8 - 15 March 2016

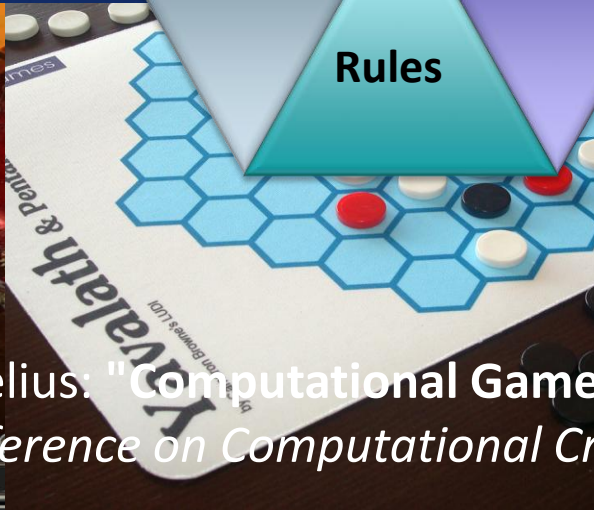
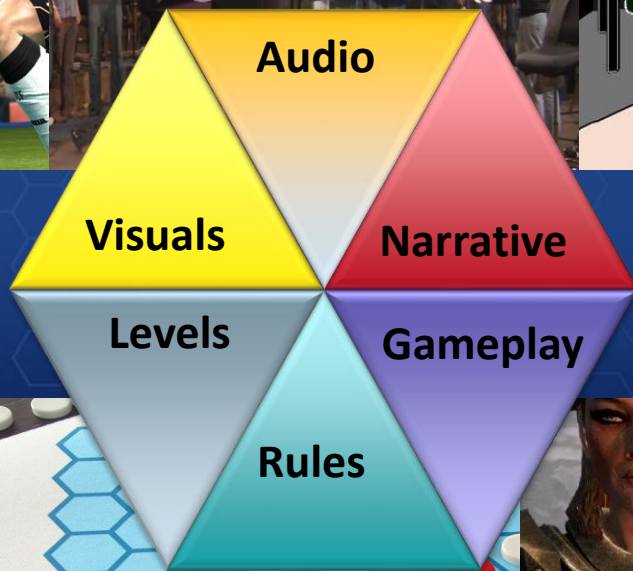


# Games realise AI's long-standing goals





# Multifaceted Creativity

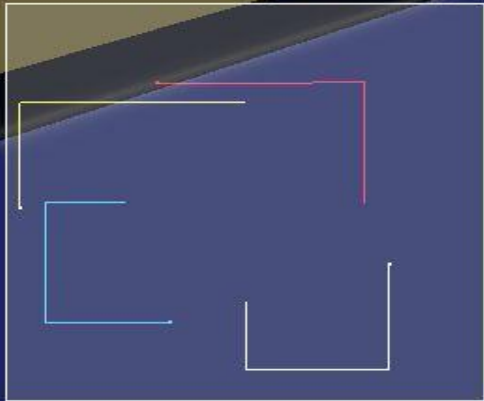
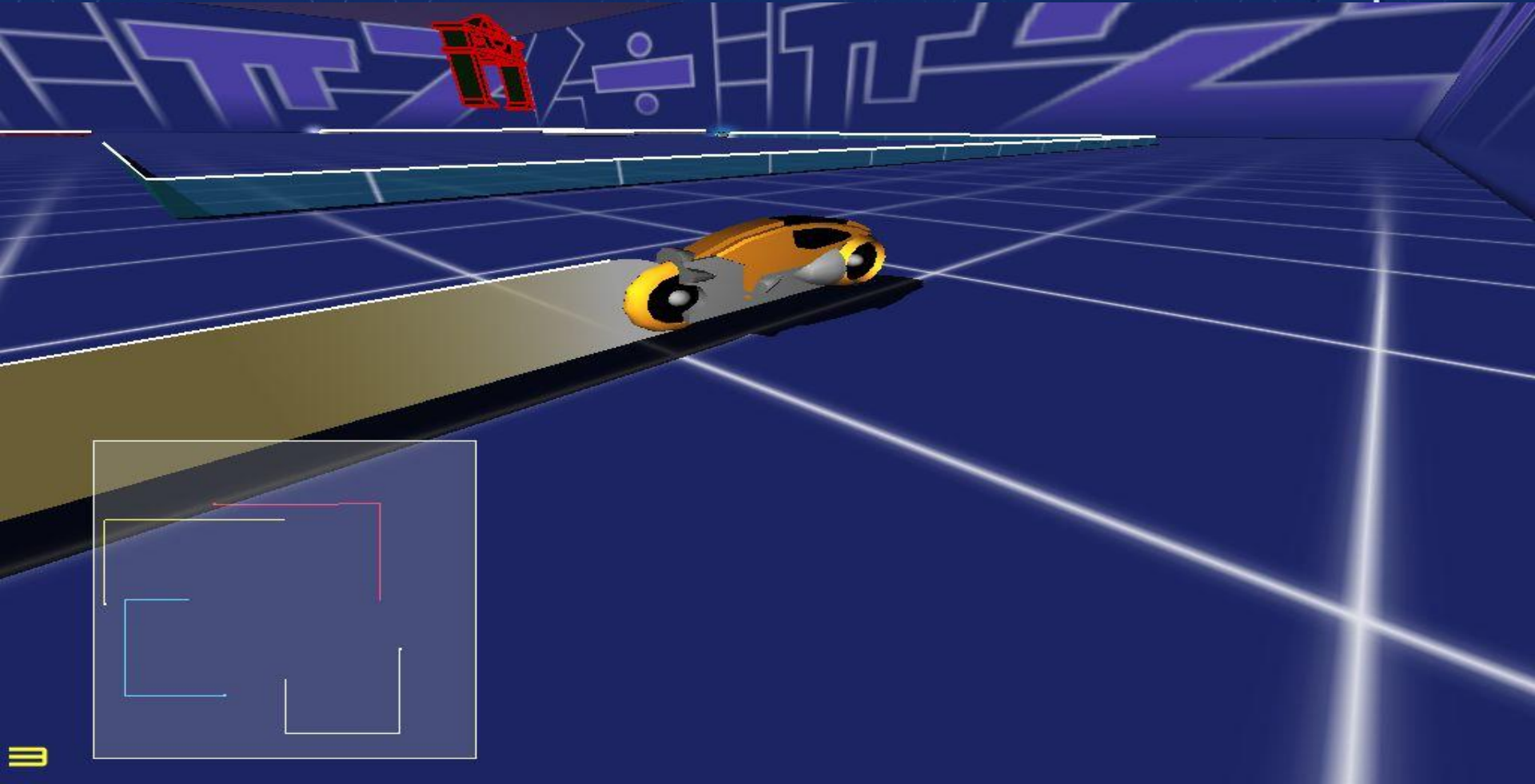


Liapis, Yannakakis, Togelius: "Computational Game Creativity," in *Proceedings of the Fifth International Conference on Computational Creativity*, 2014.

# Artificial Intelligence **for** Games



# AI Plays and Improves your Game



# Class Core Aim



- Give a comprehensive overview of **AI for games** and **games for AI**, as well as hands-on experiences with new technology
- Enable new exciting inventions and discoveries

# RANDOM LEVELS FOR ULTIMATE REPLAYABILITY

*What is Diablo 3:* "[previous] games established the series' hallmarks: randomized levels, the relentless attacks of monsters and events in a **perpetually fresh** world, [...]"

"Experience Daylight, a **procedurally generated** psychological thriller for your PC."

More Content, Better Content!





# Player Experience – Data Mining





# AI and Games: A Co-Revolution



# AI and Games History – **Academia**



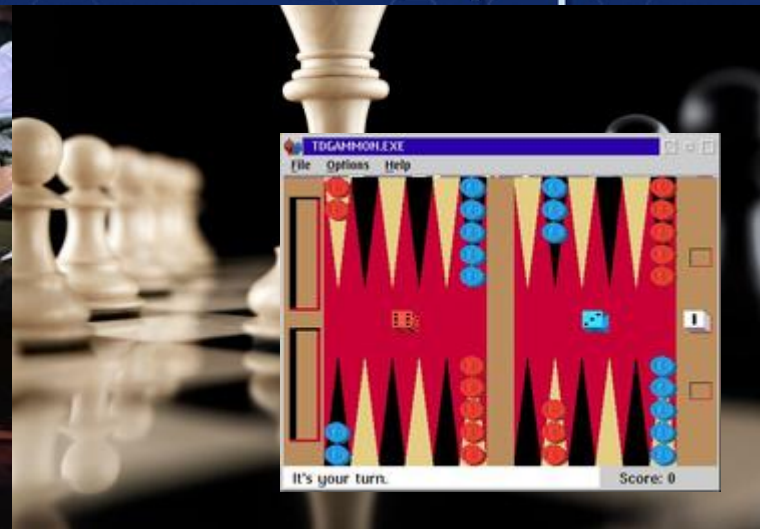


A long-lasting love (1950s)





# Early Days on the Board (60s-present)



# From Board to Video Games



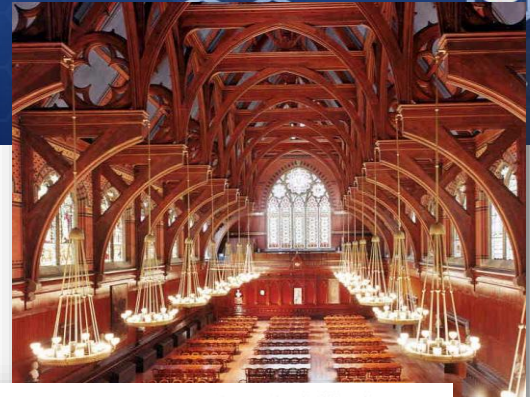
- The Game Turing test was passed by two AI-controlled bot entries in *Unreal Tournament 2004*, in 2012!
- Neuroevolution was one of the approaches



# From Board to Video Games



# From Board to Video Games



## IEEE TRANSACTIONS ON COMPUTATIONAL INTELLIGENCE AND AI IN GAMES

A PUBLICATION OF THE IEEE COMPUTATIONAL INTELLIGENCE SOCIETY, THE IEEE COMMUNICATIONS SOCIETY, THE IEEE COMPUTER SOCIETY, THE IEEE CONSUMER ELECTRONICS SOCIETY, AND THE IEEE SENSORS COUNCIL.

[www.ieee-cis.org/pubs/tciaig](http://www.ieee-cis.org/pubs/tciaig)



## IEEE TRANSACTIONS ON GAMES

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<http://cis.ieee.org/ieee-transactions-on-games.html>



IEEE  
Computational  
Intelligence  
Society



## Human-Level AI's Killer Application Interactive Computer Games

John E. Laird and Michael van Lent

■ Although one of the fundamental goals of AI is to understand and develop intelligent systems that have all the capabilities of humans, there is little active research directly pursuing this goal. We propose that AI for interactive computer games is an emerging application area in which this goal of human-level AI can successfully be pursued. Interactive computer games have increasingly complex and realistic worlds and increasingly complex and intelligent computer-controlled characters. In this article, we further motivate our proposal of using interactive computer games for AI research, review previous research on AI and games, and present the different game genres and the roles that human-level AI could play within these genres. We then describe the research issues and AI techniques that are relevant to each of these roles. Our conclusion is that interactive computer games provide a rich environment for incremental research on human-level AI.

Over the last 30 years, research in AI has fragmented into more and more specialized fields, working on more and more specialized problems, using more and more specialized algorithms. This approach has led to a long string of successes with important theoretical and practical advancements. However, these successes have made it easy for us to ignore our failure to make significant

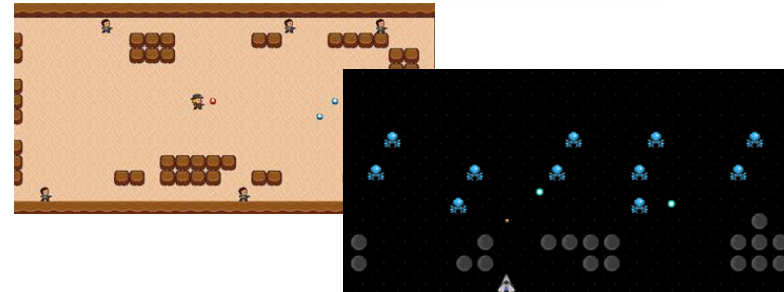
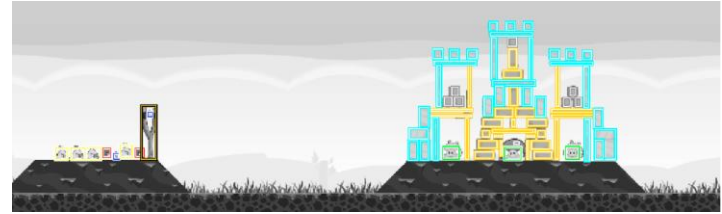
communication with natural language, commonsense reasoning, creativity, and learning.

If this is our dream, why isn't any progress being made? Ironically, one of the major reasons that almost nobody (see Brooks et al. (2000) for one high-profile exception) is working on this grand goal of AI is that current applications of AI do not need full-blown human-level AI. For almost all applications, the generality and adaptability of human thought is not needed—specialized, although more rigid and fragile, solutions are cheaper and easier to develop. Unfortunately, it is unclear whether the approaches that have been developed to solve specific problems are the right building blocks for creating human-level intelligence. The thesis of this article is that interactive computer games are the killer application for human-level AI. They are the application that will need human-level AI. Moreover, they can provide the environments for research on the right kinds of problem that lead to the type of incremental and integrative research needed to achieve human-level AI.

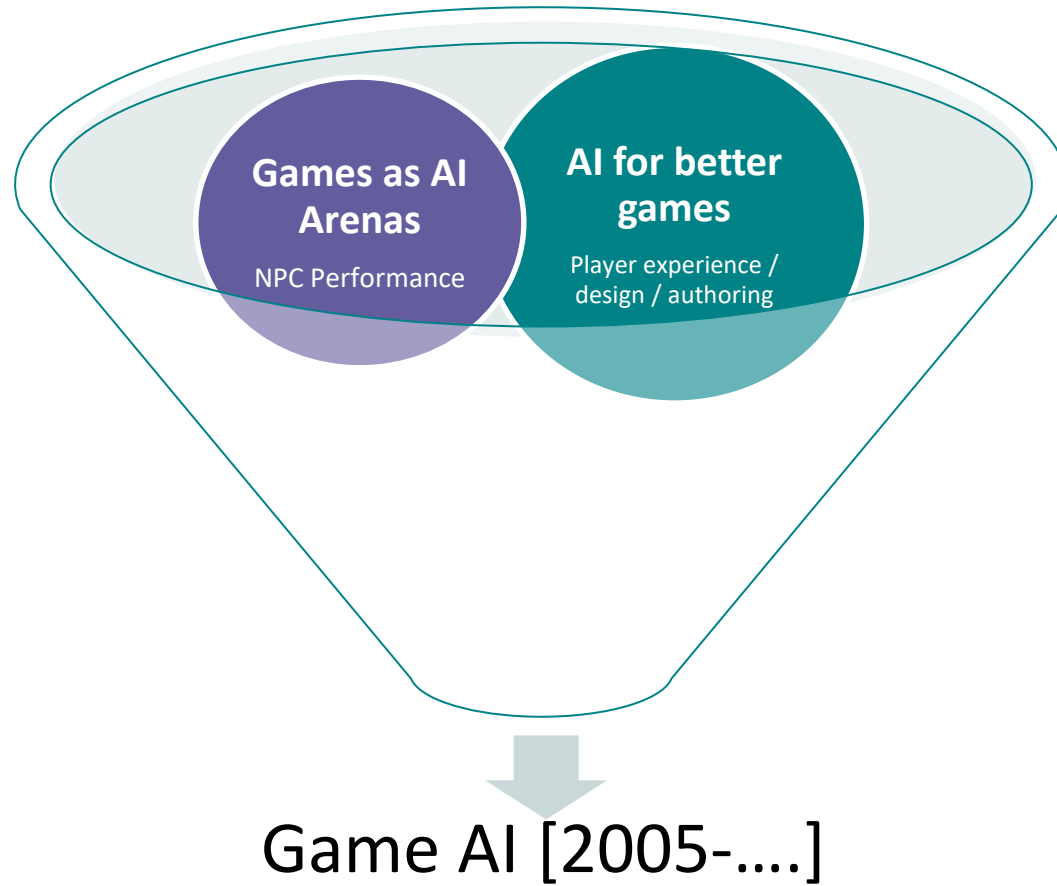
### Computer-Generated Forces

Given that our personal goal is to build human-

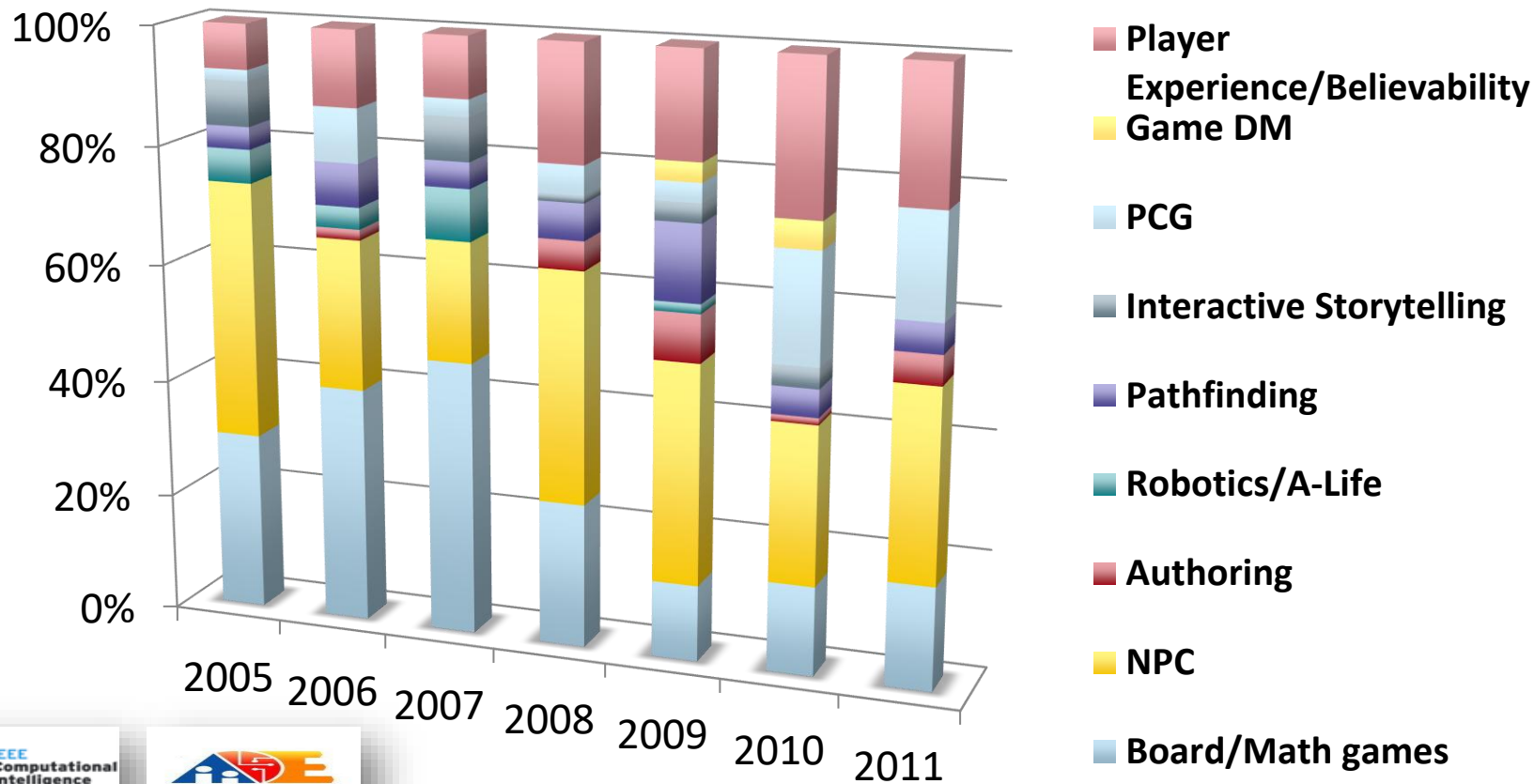
# IEEE CIG and AIIDE Competitions



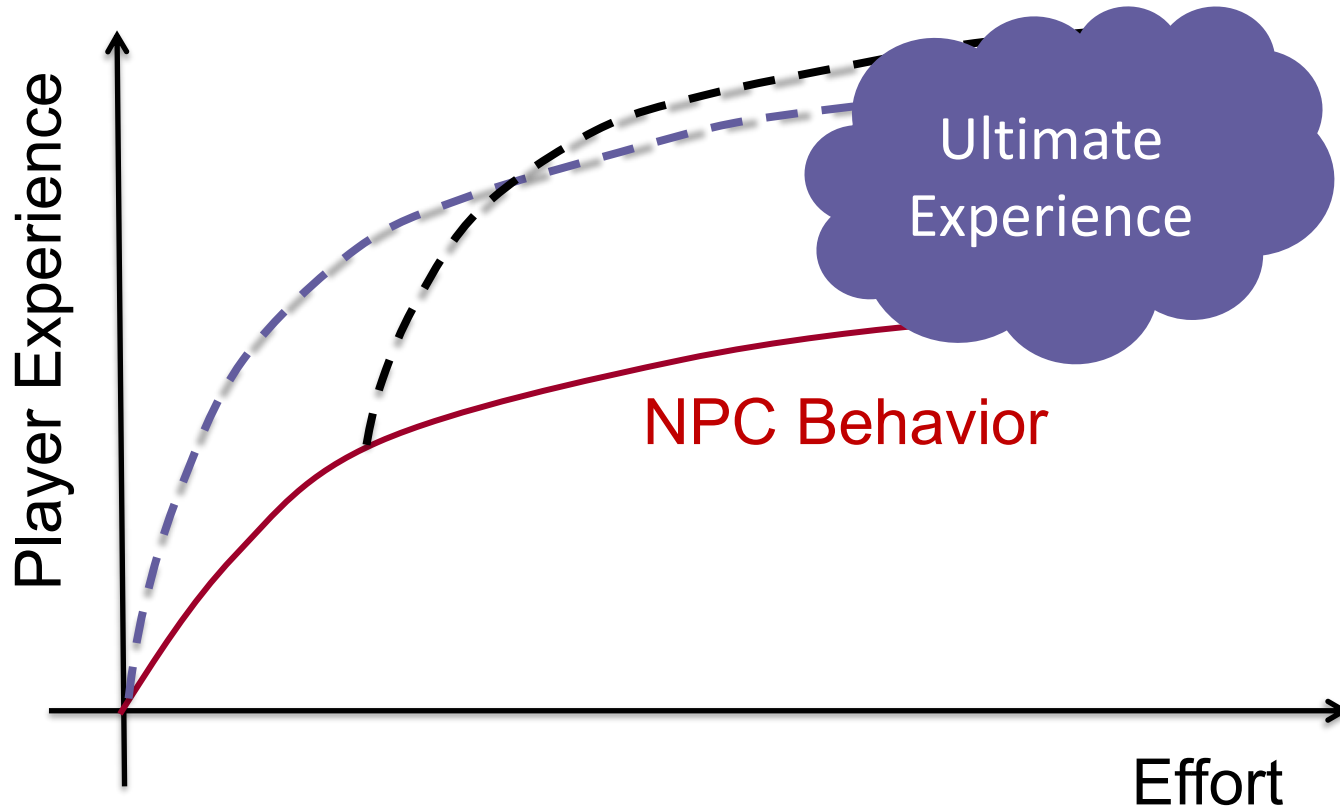
# Computer Game AI in Academia: History



# Computer Game AI



# Game AI is Dead!



Yannakakis, G. N. "Game AI revisited" *Proceedings of the 9th conference on Computing Frontiers*. ACM, 2012.

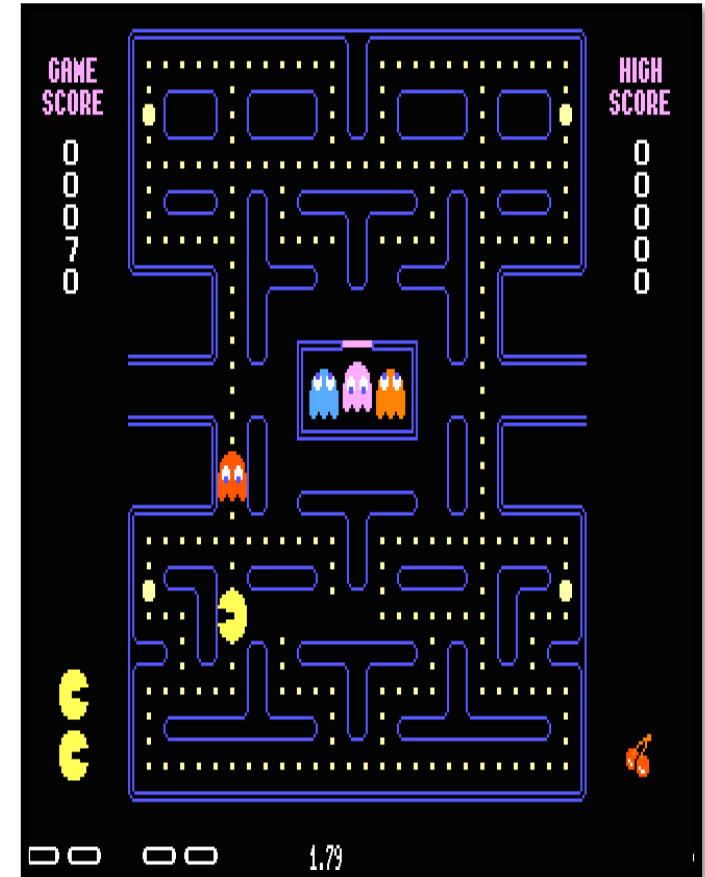
# AI and Games: A bit of history – **Industry**



# PacMan (Namco, 1980)



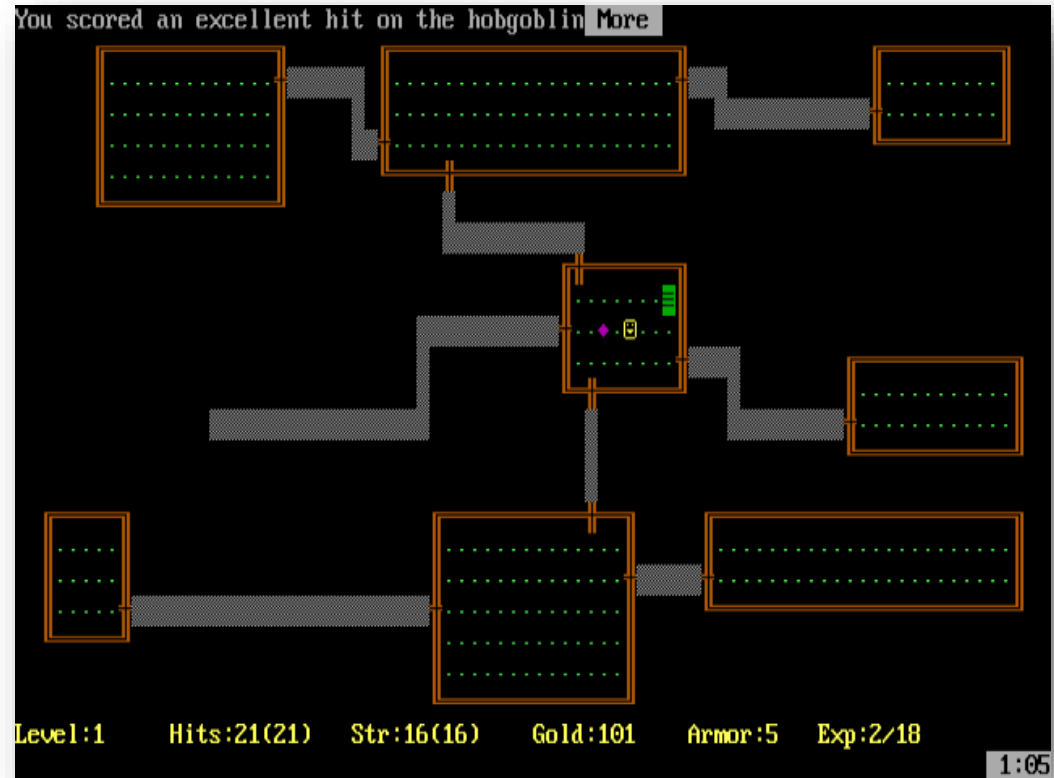
- Implicit cooperation
- Differing Ghost “Personalities”
  - Aggressive **Blinky**
  - Cunning **Pinky**
  - Wired **Inky**
  - Scared **Clyde**
- Attack – don’t care waves
- No randomness



# Rogue (AI Design, 1980)



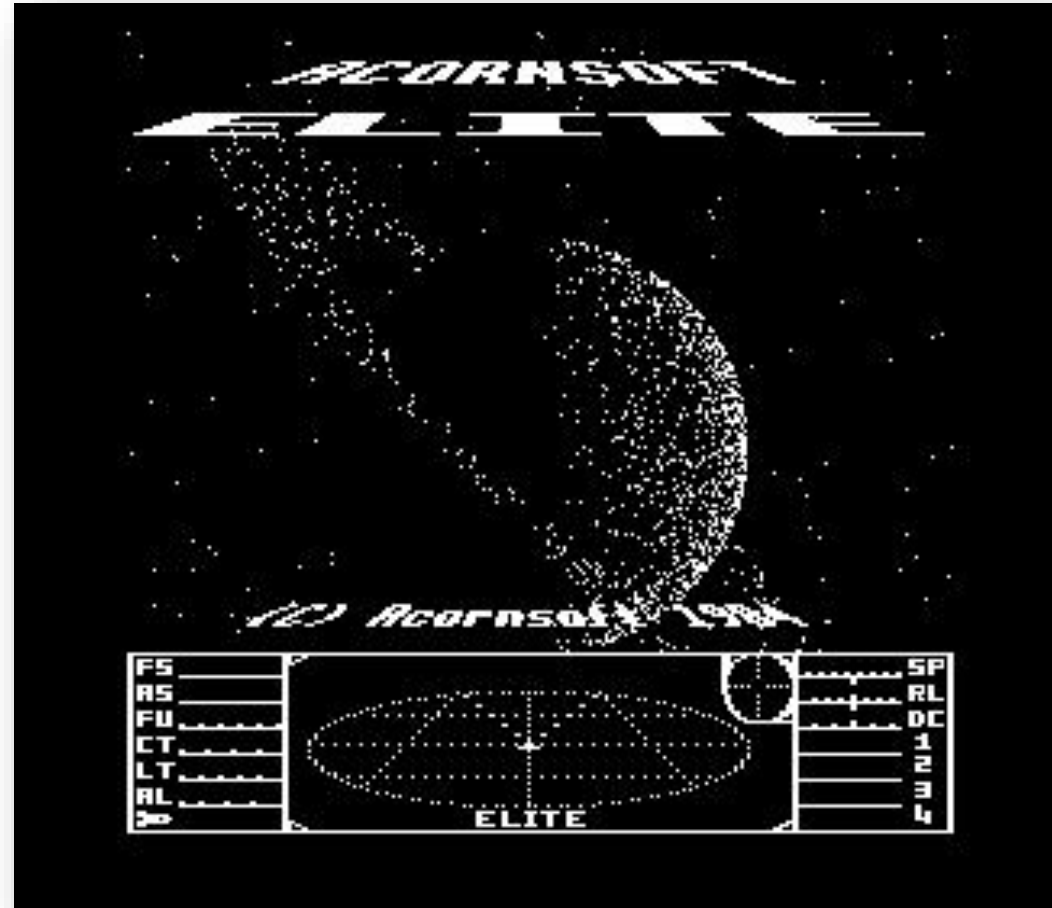
- Level generation
- Constructive approach
- Inspired rogue-like game genre



# Elite (Acornsoft, 1984)



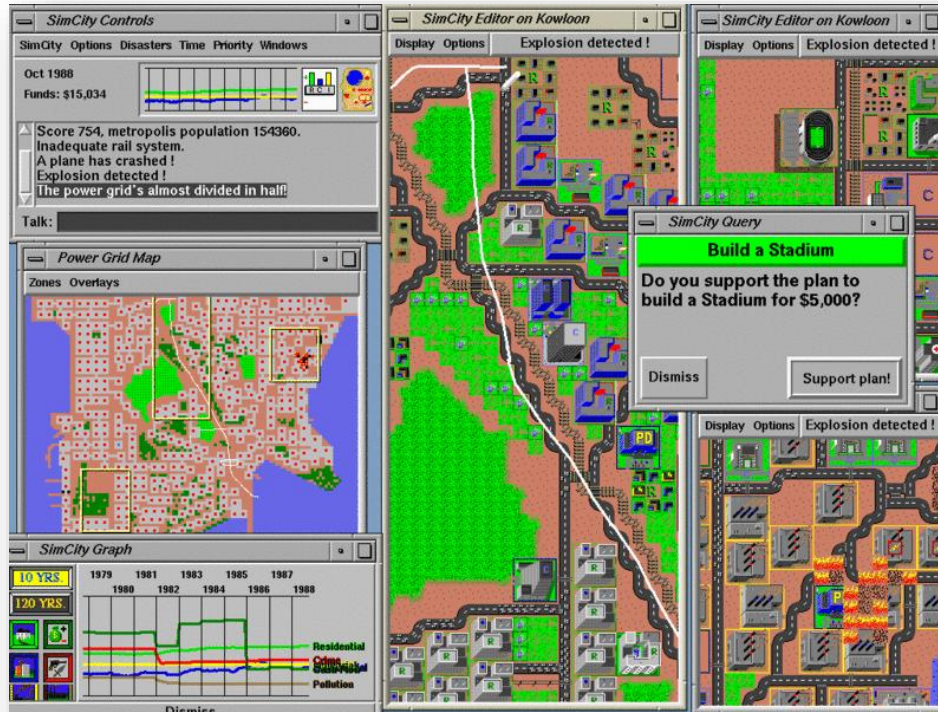
- Galaxy generation
- Compression



# SimCity (Maxis, 1989)



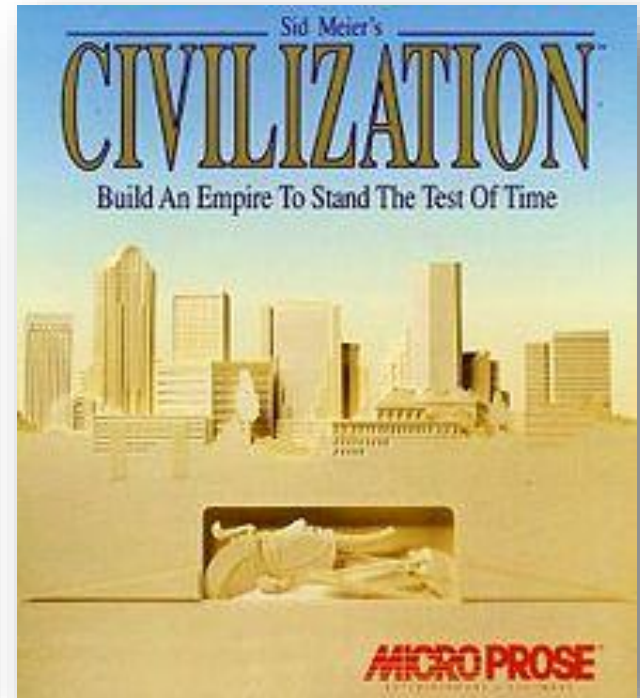
- Cellular automata
- Influence Maps



# Civilization (MicroProse, 1991)



- Map/Level generation



# *Creatures* (Millennium Interactive, 1996)



# *Thief* (EIDOS, 1998)



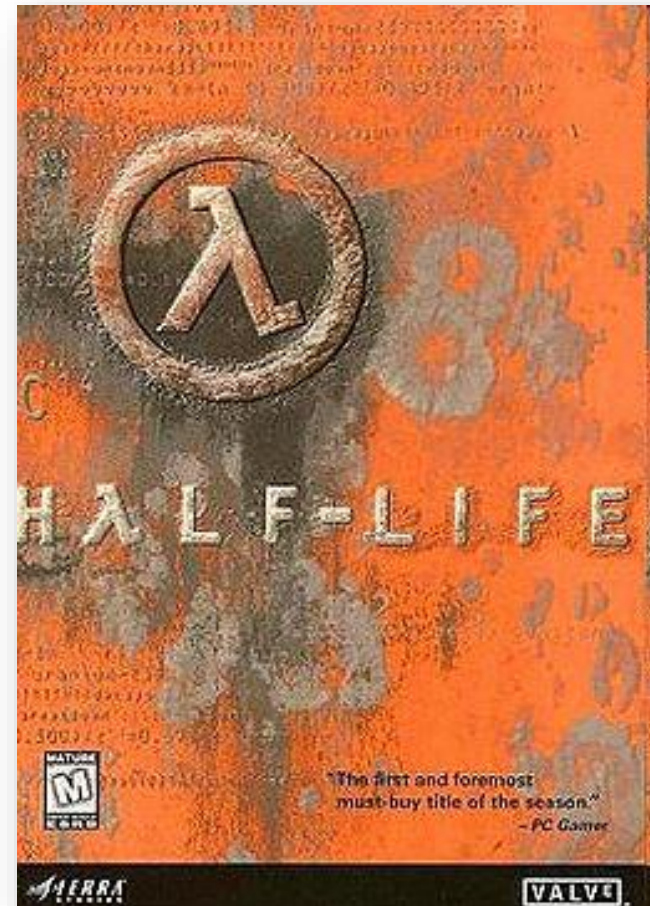
- Stealth FPS, FP-Sneaker
- Advanced sensory system
- Guards perceive and respond to the environment
  - Noise, lighting, movement, and shadows.



# Half-Life (Valve, 1998)



- FPS + puzzle solving
- Opponent Tactics
  - Coverage, dodging, full-level navigation
- Integration of AI into the story
- Valve hired Quake AI Mod developers for HL 2



# *Sims* (EA, 2000)



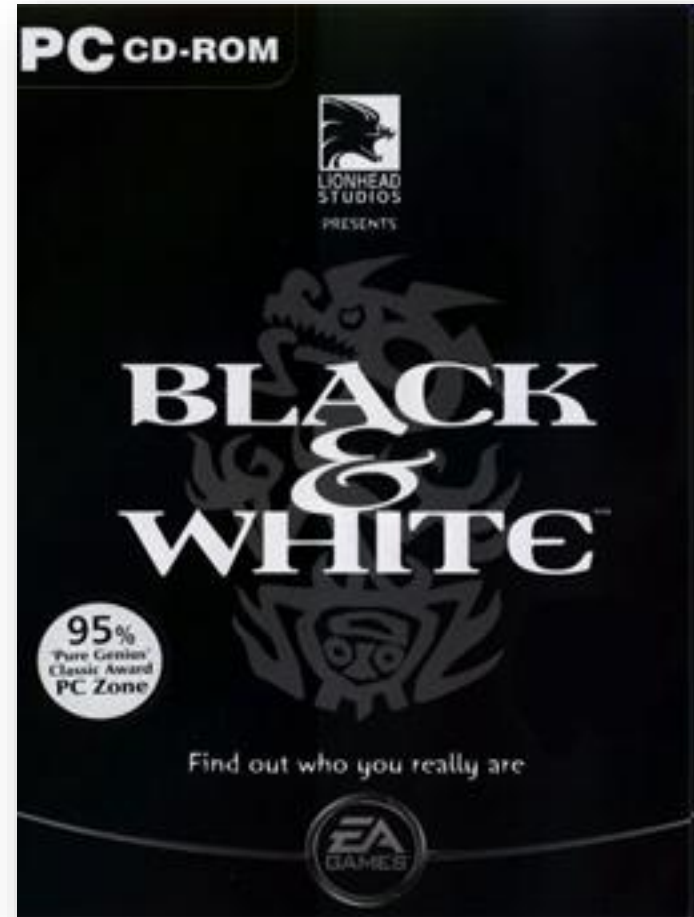
- Smart (interactive) terrains
- Smart (interactive) objects



# Black & White (EA, 2000)



- Perceptrons, Decision Trees, Belief-Desire-Intentions model
- Imitation Learning
- Reinforcement learning: creature slapped or stroked
- Gesture recognition



# Halo 2 (MS Game Studios, 2004)



- The revolution of **Behavior Trees**
- More human-like bots



# F.E.A.R. (Sierra, 2005)



- Best AI opponent – bot (at the time)
- Bot squads, teammate behaviors
- Cover when hit from behind
- Intelligent tactics
- Move through walls and under objects
- Planning system based on STRIPS
- “Environments to showcase the AI”



# Forza Motorsport (MS game studios, 2005)

- Drivatar system
- Imitation Learning
- MS Research – Cambridge



# *Façade* (Mateas & Stern, 2005)



- Interactive Storytelling
- Natural Language Processing
- AI faults: absorbed by game (character) design

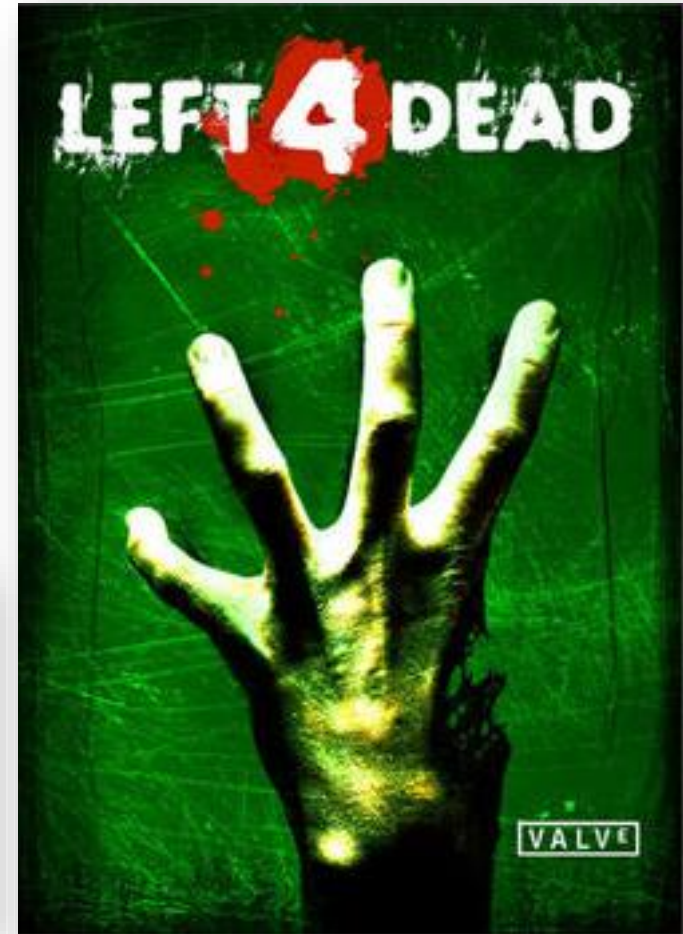
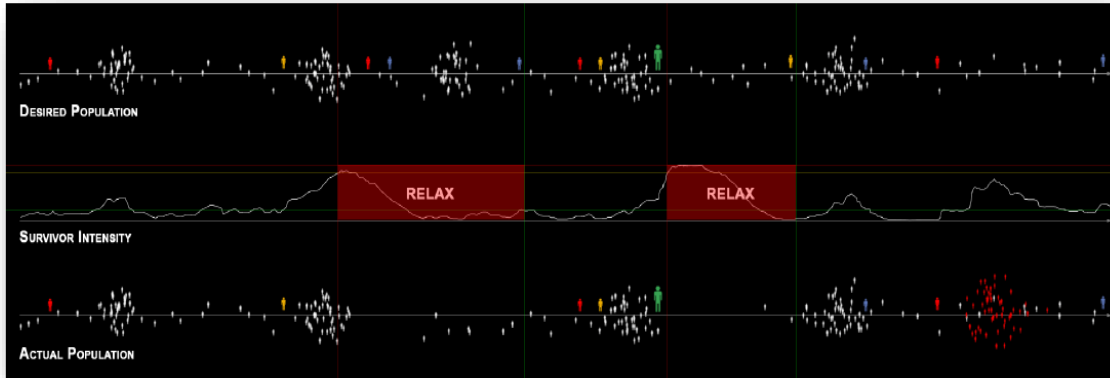


# Left 4 Dead (Valve, 2008)



- **AI director**

- Intelligent enemy placement
- Intelligent item placement
- Player emotional cues (visual effects, dynamic music)



# Spelunky (Mossmouth, 2008)



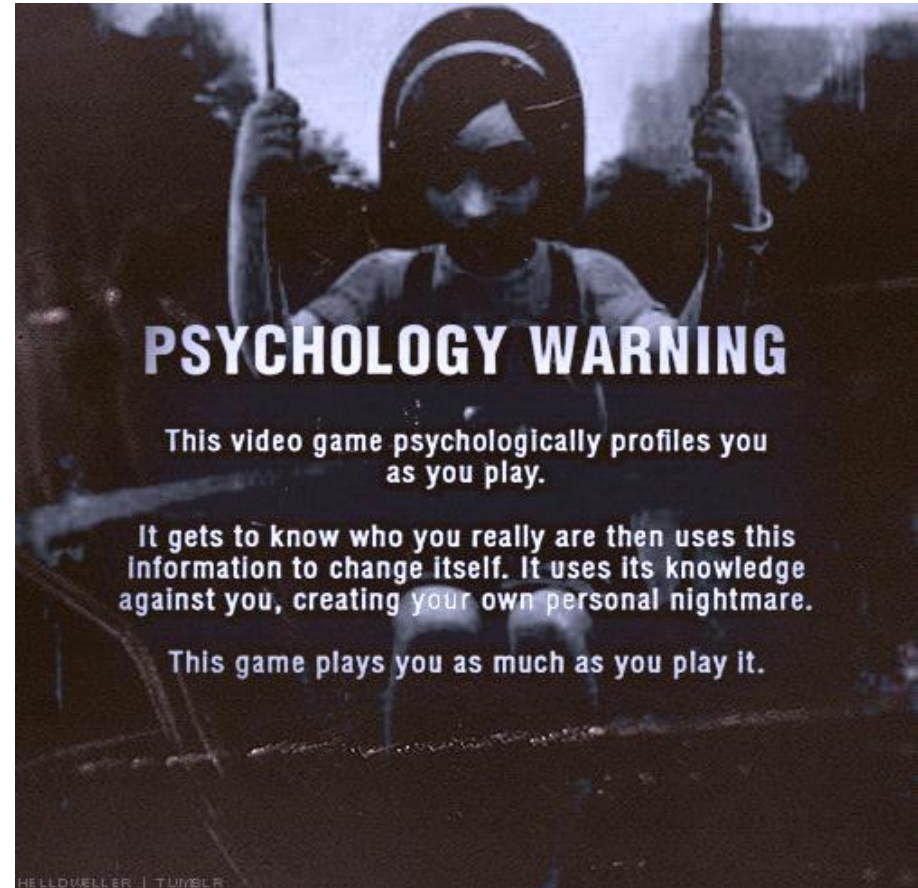
- Level generation
- Ultimate re-playability
- Guarantees playability



# *Silent Hill* (Konami, 2010)



- Survival horror
- Personality-based adaptation



# Heavy Rain (Quantic Dream, 2010)



# Various Kinect Games (2010 – ...)



- E.g. Kate & Milo (demo), Kinectimals, etc..
- Affective AI
- Posture (fully body) Recognition
- Speech recognition



# *Bioshock Infinite* (2k Games, 2013)



# *Nevermind* (Flying Mollusk, 2016)



NEVERMIND

# *No Man's Sky* (Hello Games, 2016)



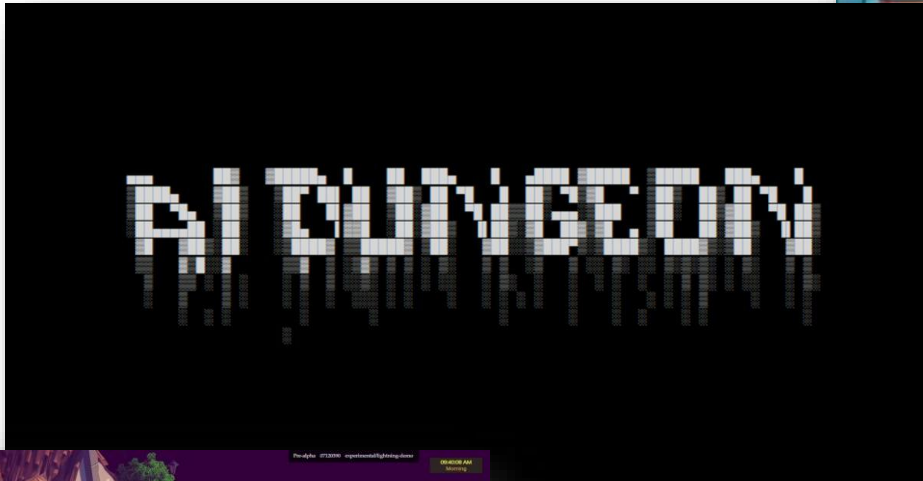
20s



TOWNSCAPER

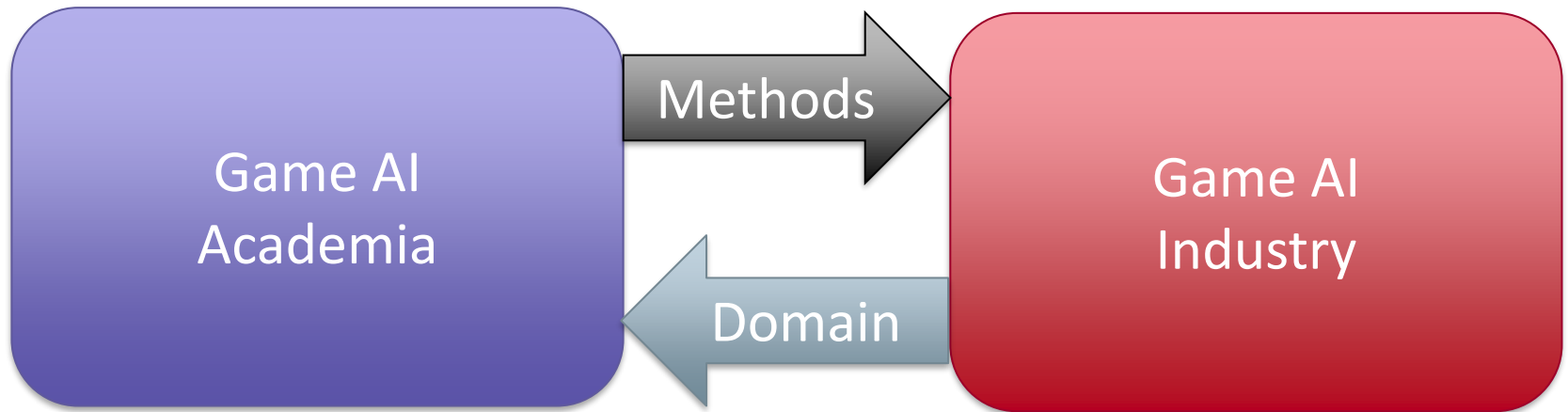


NO DUNGEON

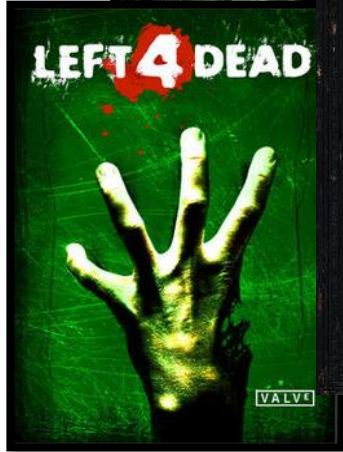


Infinite  
Craft

# The “Gap” Between Academia and Industry



# Some Facts about the “Gap”



AI Summit

GDC

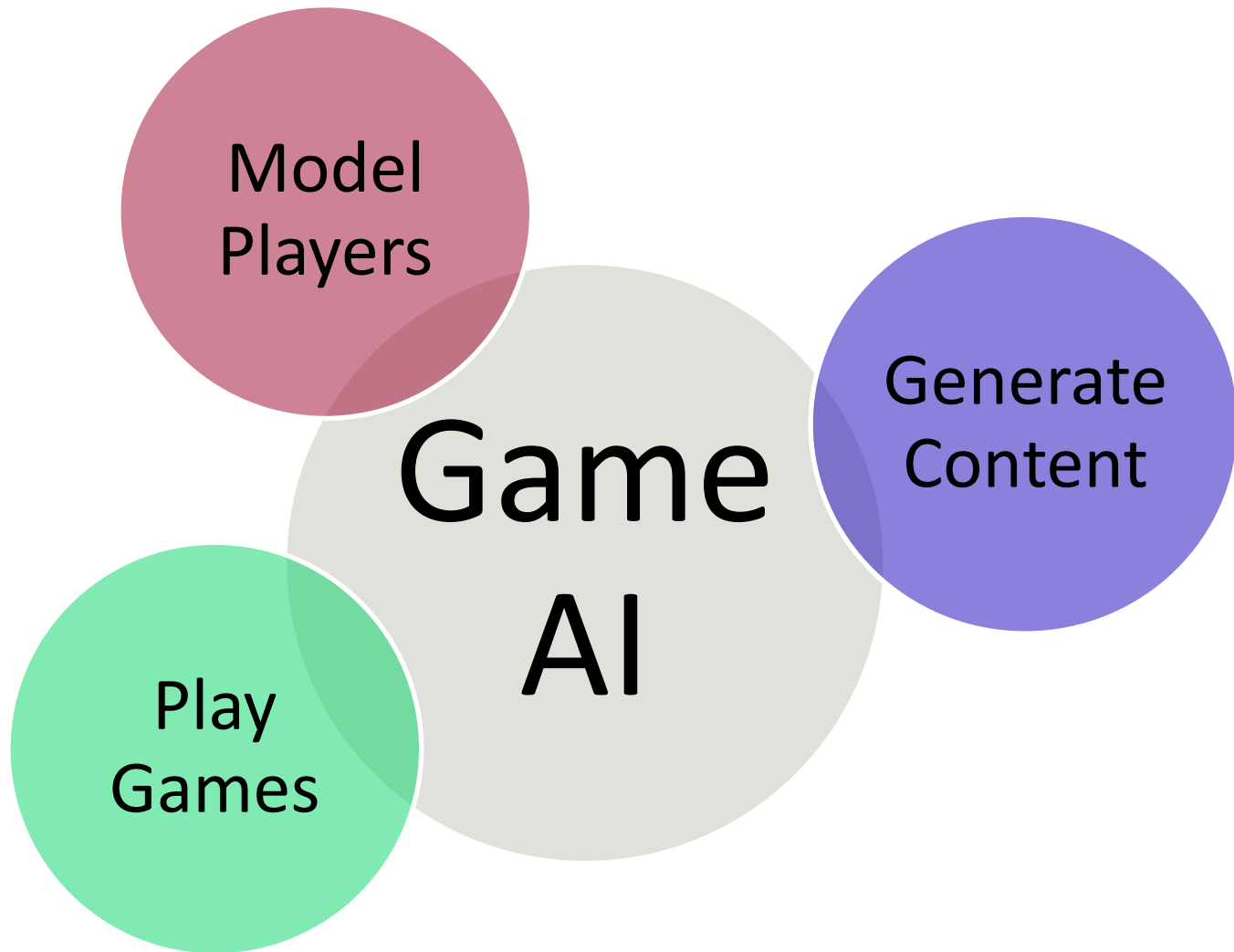
Games helps us design **better** AI...

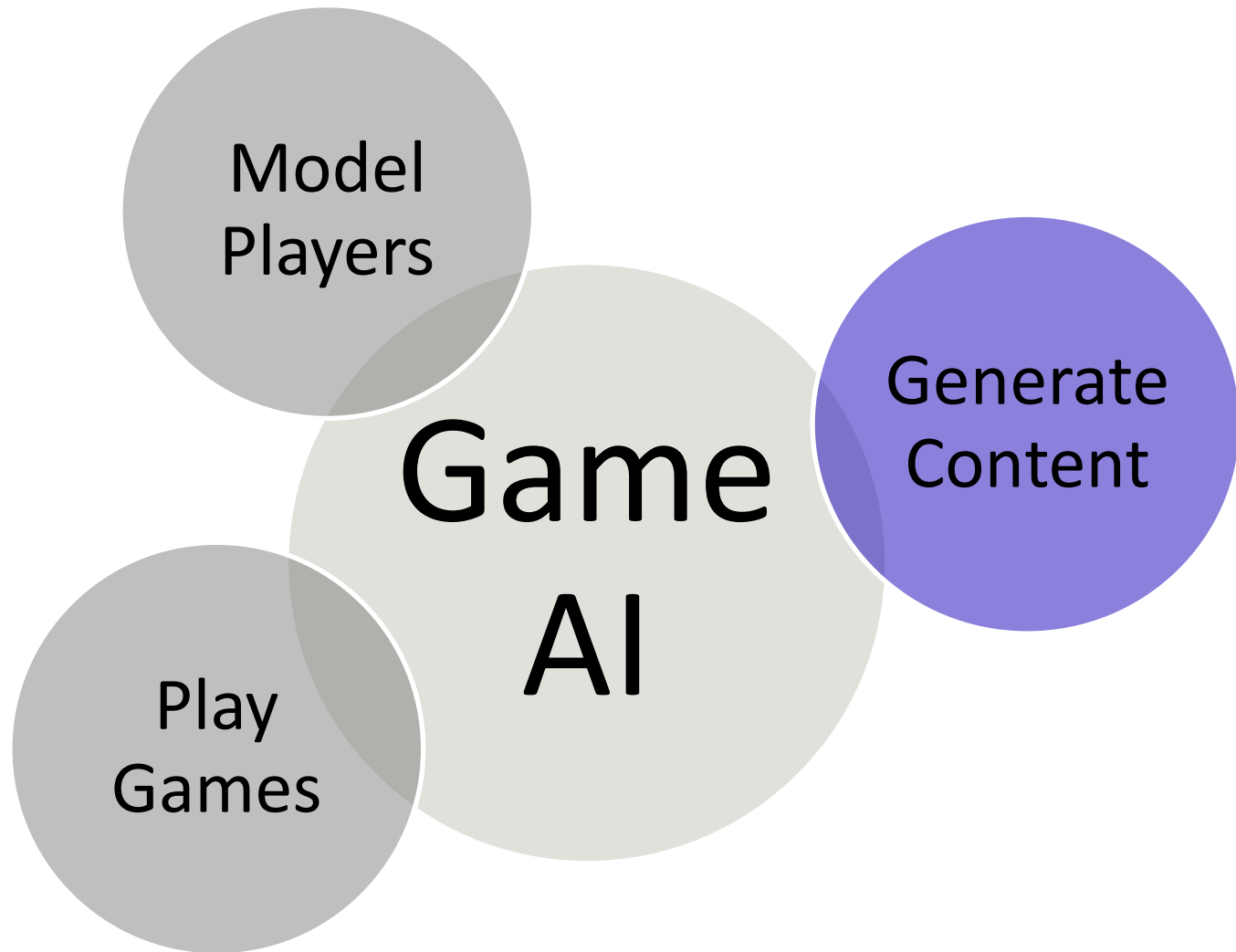
...and AI can help us make **better** games ...

...but not necessarily through **game agents!**

**How then?**

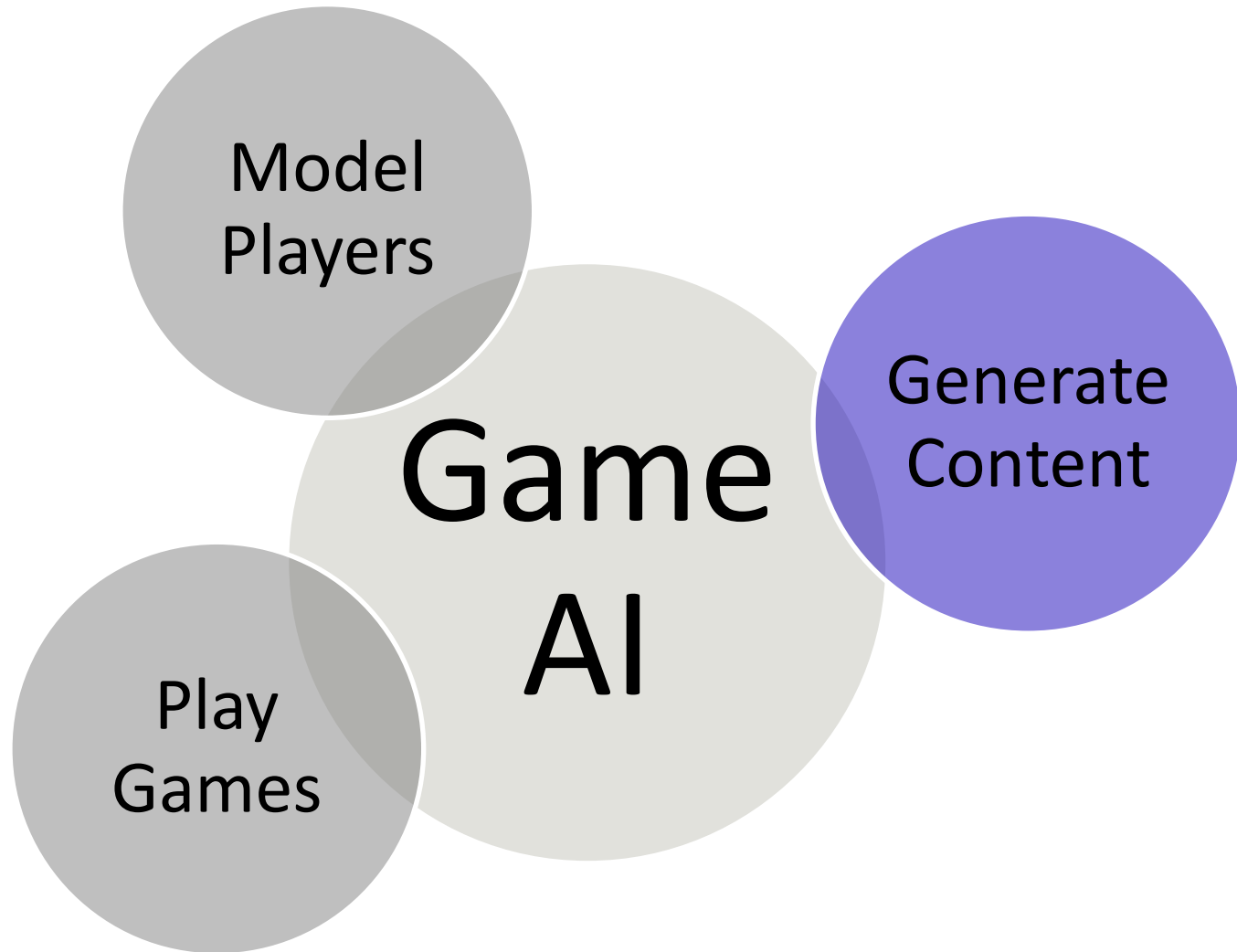
G. N. Yannakakis, “**Game AI Revisited**,” in *Proceedings of the 9th ACM Computing Frontiers Conference*, pp. 285-292, 2012. (invited paper)

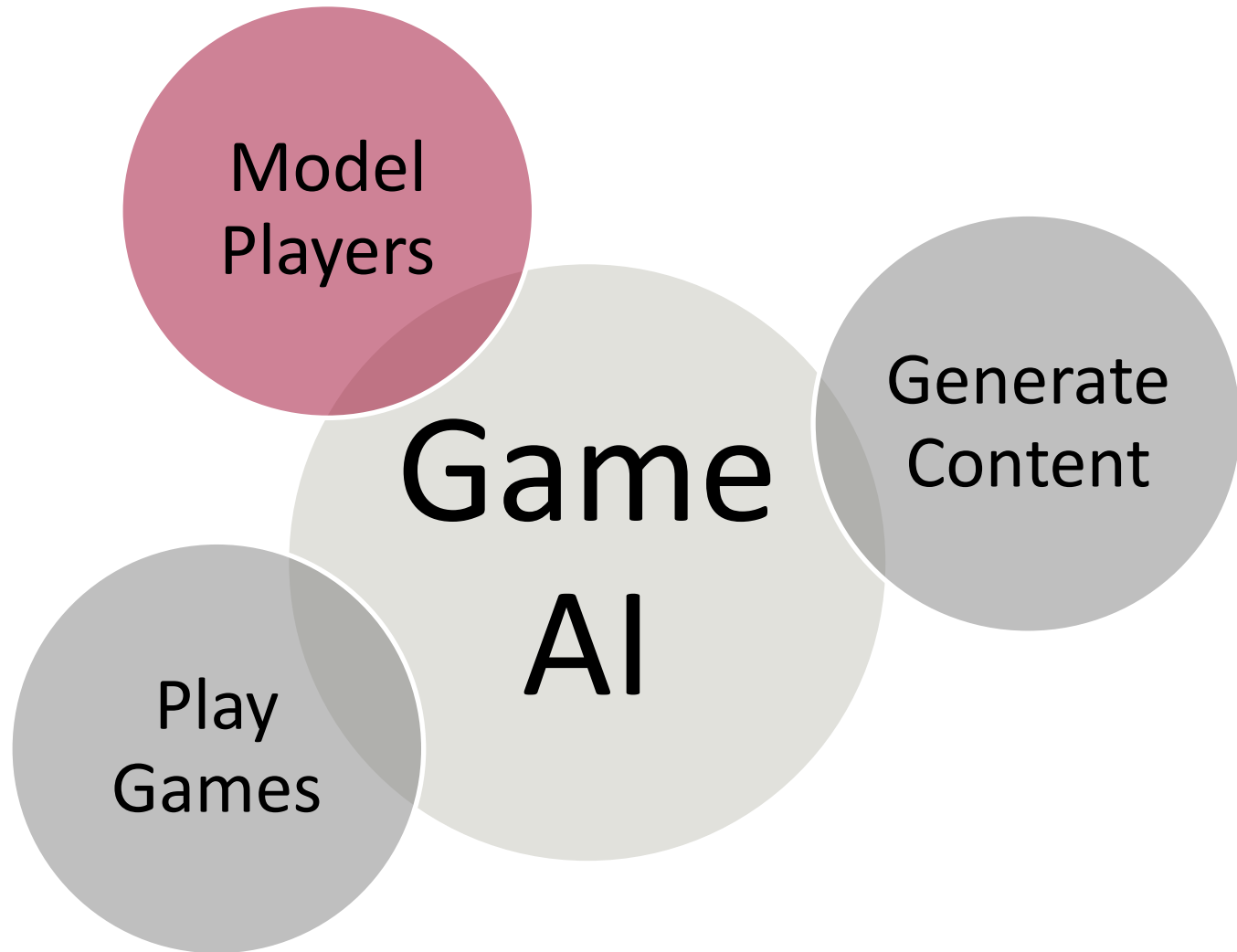




# Procedural Content Generation







**“Games cannot be  
dissociated from emotion  
and learning...”**

G. N. Yannakakis and A. Paiva “**Emotion in Games,**” in *Oxford Handbook of Affective Computing*, 2014



# Player Modeling



“Games: the **final frontier** for AI?”

“AI: the **next step** for Games!”

# Artificial Intelligence and Games

A Springer Textbook | By Georgios N. Yannakakis and Julian Togelius



About the Book

Table of Contents

Lectures

Exercises

Resources

## About the Book

### Second Edition Published!

Welcome to the Artificial Intelligence and Games book (2nd edition) published with Springer Nature in 2022. This is the first comprehensive textbook on the application and use of artificial intelligence (AI) in, and for, games. The book will be used by educators and students of graduate or advanced undergraduate courses on game AI and by practitioners at large.

# Readings: Chapter 1

[gameaibook.org](http://gameaibook.org)

