Spore creature
Ben Porter, 2008

Lecture 2a & 2b

A History of Applications for Artificial Intelligence, Artificial Life and Virtual Environments

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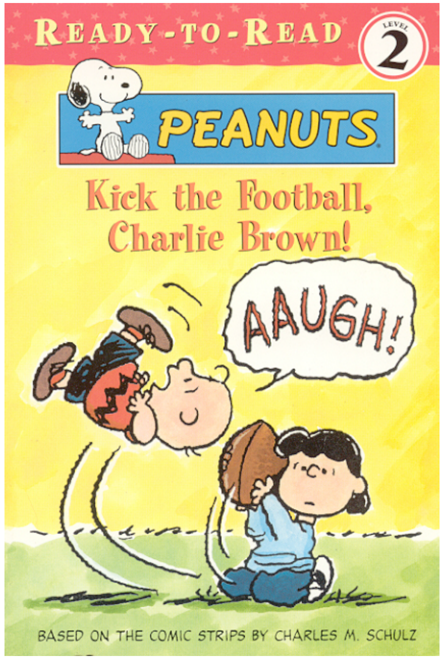
FIT3094 Artificial Life, Artificial Intelligence and Virtual Environments

MONASH University
Information Technology

Differences between science and game AI, AL and virtual environments.

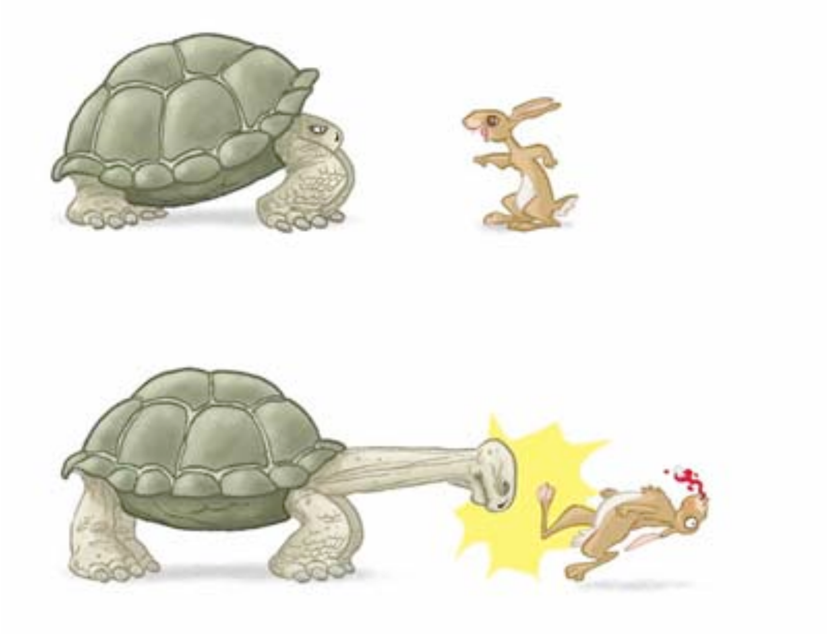
The sciences of Artificial Intelligence and Artificial Life aim to understand biological intelligence and life, or to replicate them *in-silico*.



The AI and AL game designer has a slightly different goal:

Make an interesting game that is fun to play *and* that gives the illusion of sentience, intelligence and life in its non-player characters or computer opponents.

Make the game world challenging and/or rich to explore.



Few people enjoy playing against an opponent who is:

- too fast
- too skilful
- a cheat

Cartoon by Floor de Goede
http://www.doyouknowflo.nl/

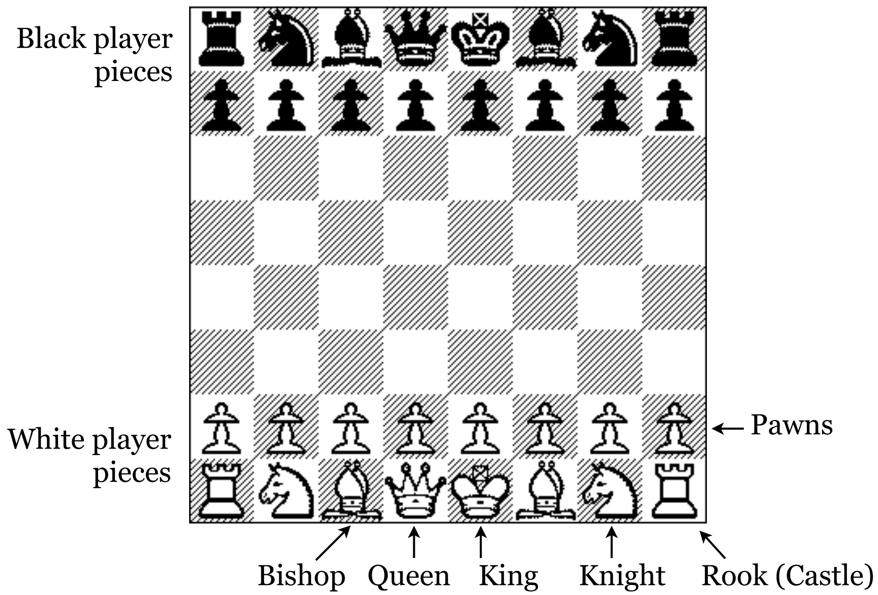
The virtual player: a hidden artificial, intelligent opponent

In many games, the human player competes against a program that takes on the role of a human opponent by making visible moves on a board or in a game world.... chess, go, draughts, backgammon, noughts and crosses, poker, realtime strategy games etc...

The Seventh Seal (Swedish: Det sjunde inseglet), Ingmar Bergman, 1957

A summary of the rules of chess

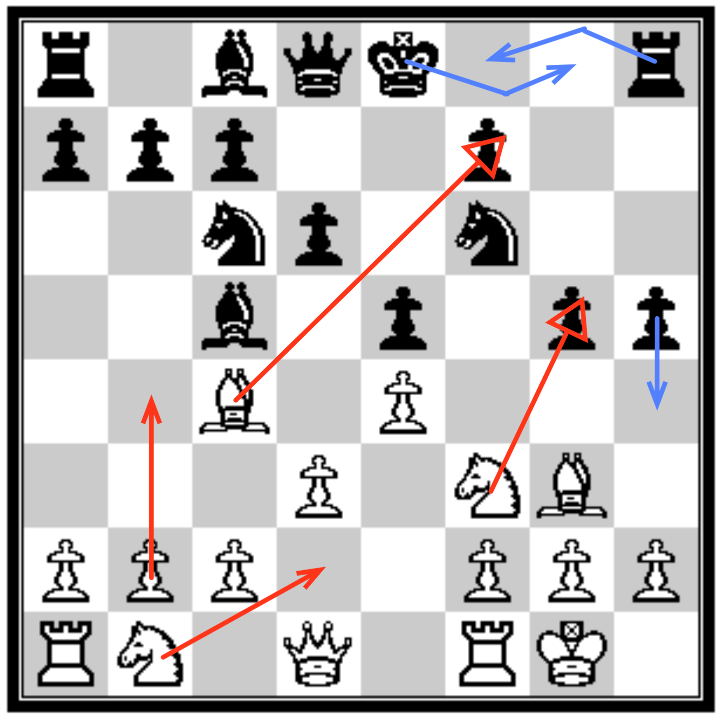
In the beginning...



Each piece has has a repertoire of legal moves depending on its type.

A piece captures an opponent's piece by moving on top of it.

Sample legal moves...

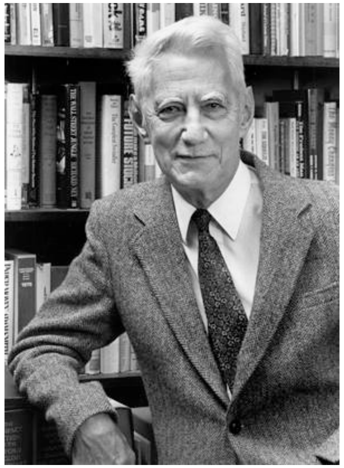


The objective is to *checkmate* the king of the opponent by moving and positioning your own pieces. Checkmate signifies that the opponent's king will be captured at the next move.

Protecting your own king and obtaining strong board positions are needed for success.

AI and chess

Claude Shannon...



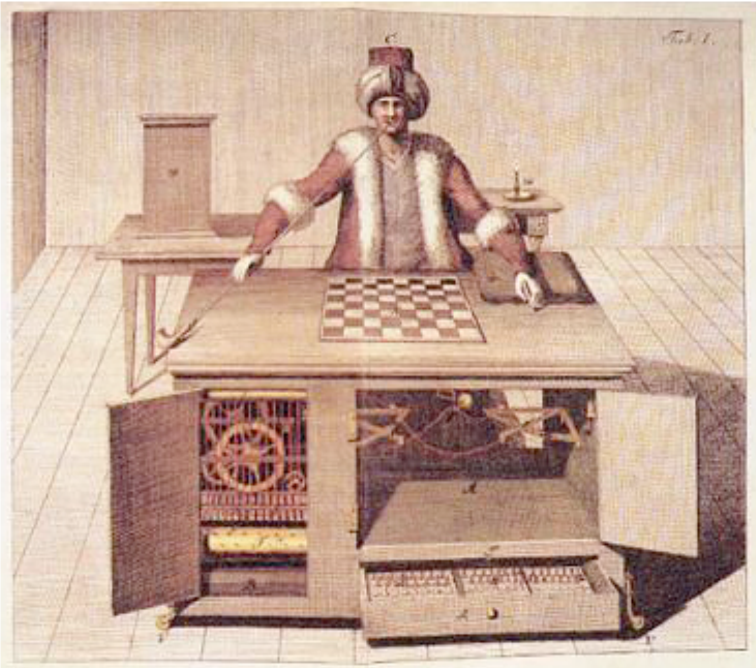
Claude Shannon
(1916 – 2001)

The chess machine is an ideal one to start with, since:

1. the problem is sharply defined both in allowed operations (the moves) and in the ultimate goal (checkmate);
2. it is neither so simple as to be trivial nor too difficult for satisfactory solution;
3. chess is generally considered to require "thinking" for skilful play; a solution of this problem will force us either to admit the possibility of a mechanised thinking or to further restrict our concept of "thinking";
4. the discrete structure of chess fits well into the digital nature of modern computers.

Of course an automated chess partner is also entertaining and good for practicing your game.

Shannon, C.E., Programming a Computer for Playing Chess. *Philosophical Magazine*, Ser.7, Vol. 41, No. 314 - March 1950.



Baron Wolfgang von Kempelen constructed this famous automaton, a *Chess-Playing Turk* (1769).

This was used to amuse the ticket-paying elite of European society. Even Napoleon was said to have been beaten by it…

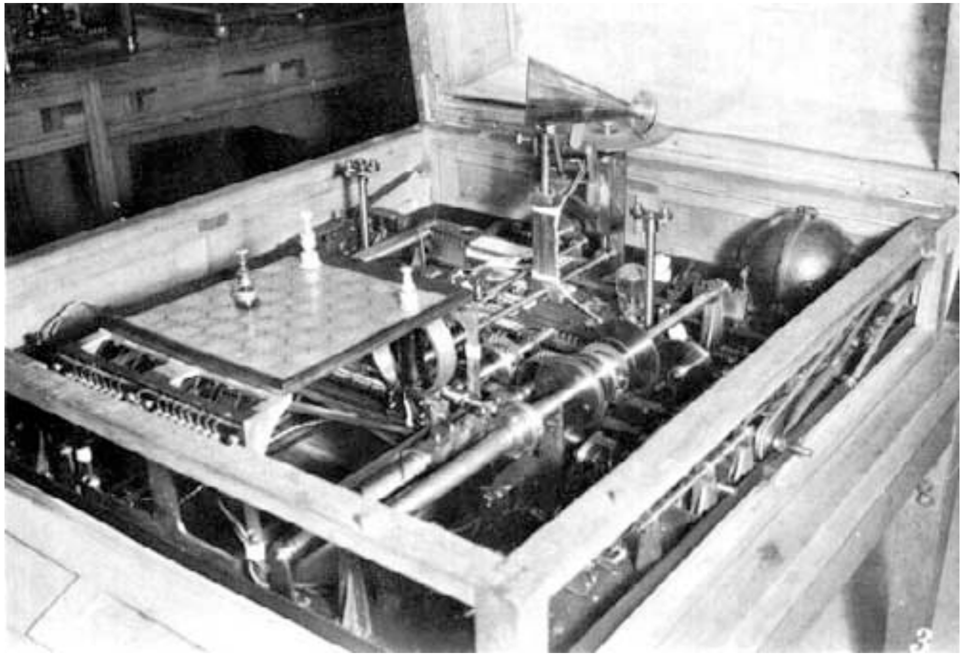
The Turk played a very good game!

Reading: Wood, G. (2003). *Living Dolls, A Magical History of the Quest for Mechanical Life*. Kent, Faber and Faber (chapter 2).

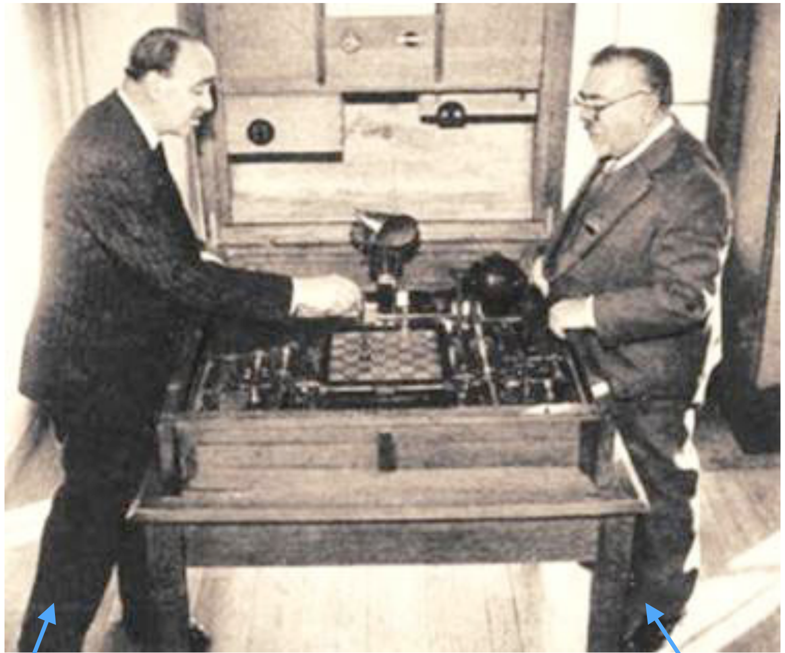
El Ajedrecista

Leonardo Torres y Quevedo's *Chess-player*

Version 1, 1910-1914 (mech. arm to move pieces)
Version 2, 1920 (magnets beneath the board)



Version 2



1951 demonstration

Leonardo Torres y Quevedo

Norbert Wiener

How can a machine play chess?

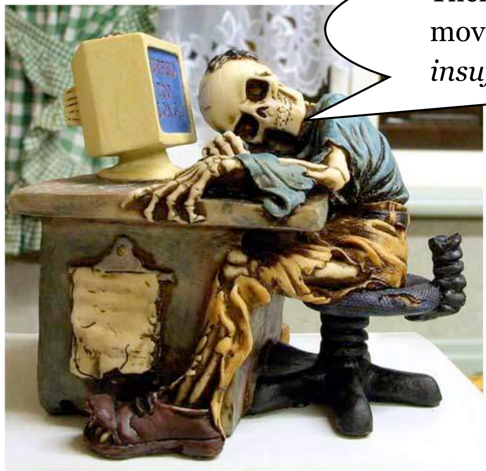
http://history-computer.com/Dreamers/Torres_chess.html

Shannon's computer chess strategies

Brute force (type A)

1. List the legal moves possible in the present position.
2. Take the first in the list and try this move.
3. List the Black moves from the present position.
4. Apply the first one and evaluate* the board state.
5. Apply the second Black move and evaluate.
6. Compare, and reject the move with the smaller evaluation.
7. Continue with the third Black move and compare with the retained value, etc.
8. When the Black moves are exhausted, one will be retained together with its evaluation. The process is now repeated with the second White move.
9. The final evaluation from these two computations are compared and the maximum retained.
10. This is continued with all White moves until the best is selected (i.e. the one remaining after all are tried). This is the move to be made.

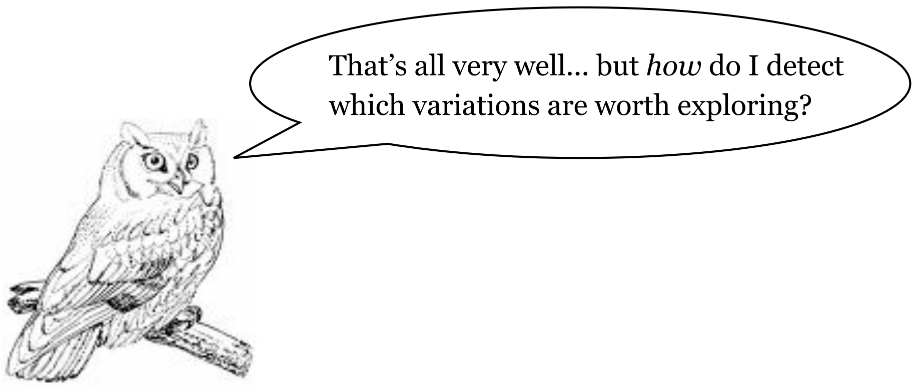
There are about 10^9 positions to be evaluated after 3 moves for each side and a look-ahead of 3 moves is *insufficient* for a good game.

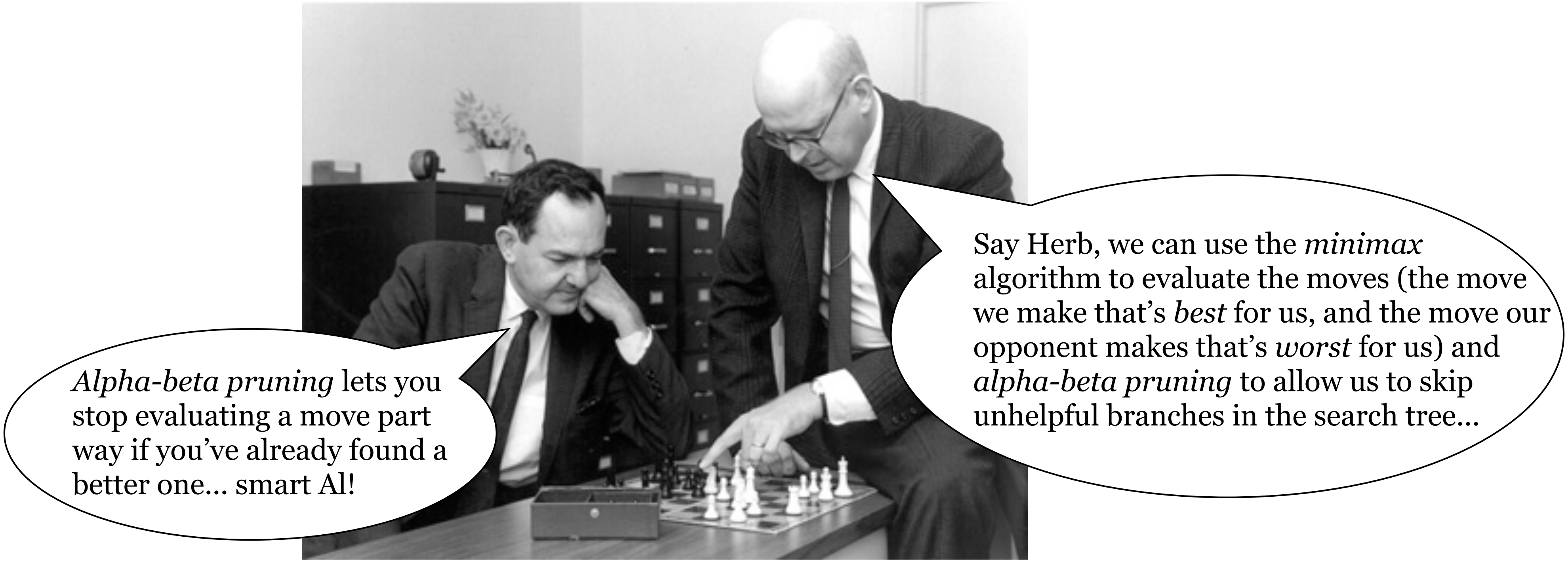


* Calculate the "value" of this state to the player

Selective search (type B)

- Examine forceful variations out as far as possible and evaluate only at reasonable positions, where some quasi-stability has been established.
- Select the variations to be explored by some process so that the machine does not waste its time in totally pointless variations.





Herbert Simon

Allen Newell

During the 50s, 60s and 70s chess was tackled by many…

Dr. Dietrich Prinz

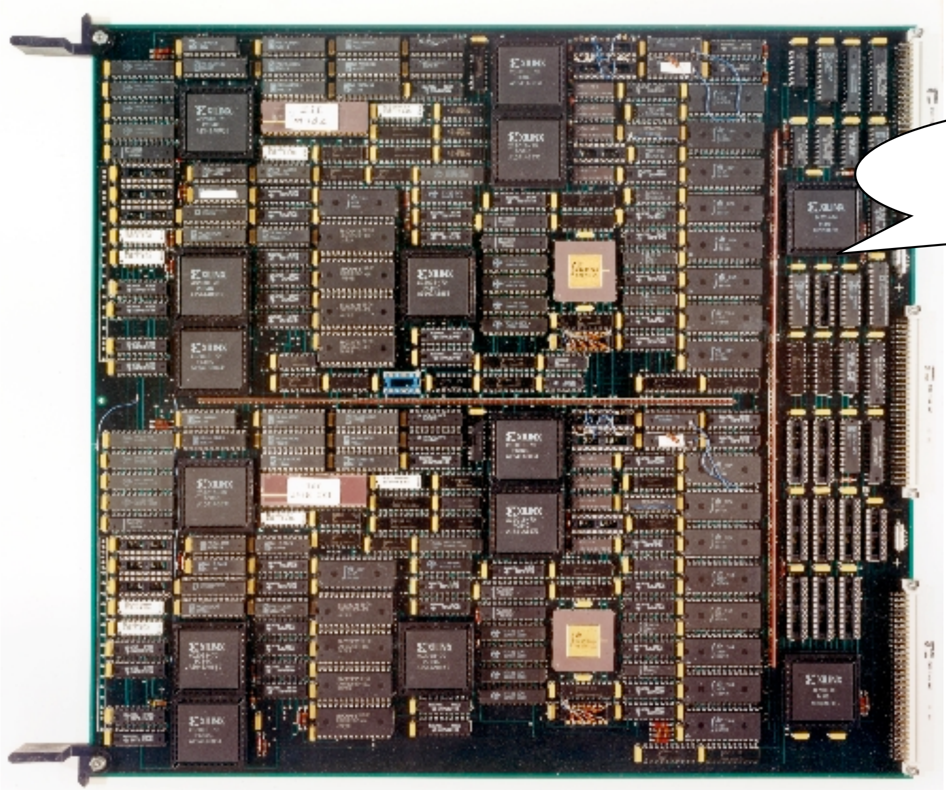
Courtesy of Hulton-Deutsch Collection/CORBIS
L062302008

Dr. Dietrich Prinz worked as a research scientist on the Ferranti Mark I computer in collaboration with Manchester University. His interest in computer chess was probably influenced by his colleague Alan Turing. Prinz is shown here loading a rudimentary chess program into a Manchester University computer in 1955.

The first all-computer chess tournament was held at the Association for Computing Machinery's (ACM) annual convention in 1970.

By the end of the decade many of the top programs could play *Expert* chess (US Chess Federation 2000 level).

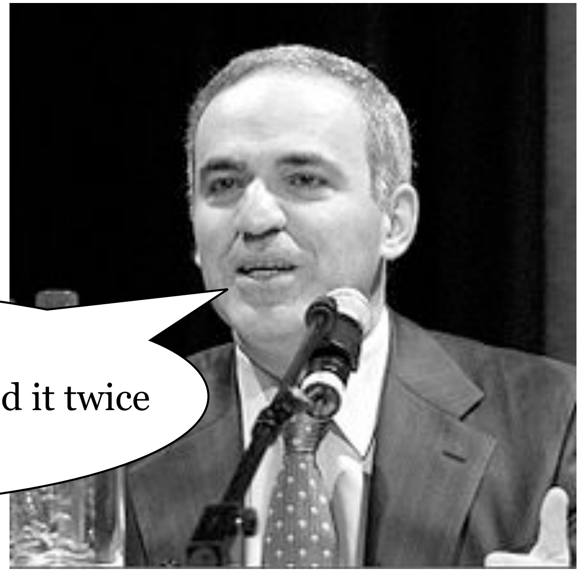
Computers kept getting faster…



Deep Thought I circuit board (1988)

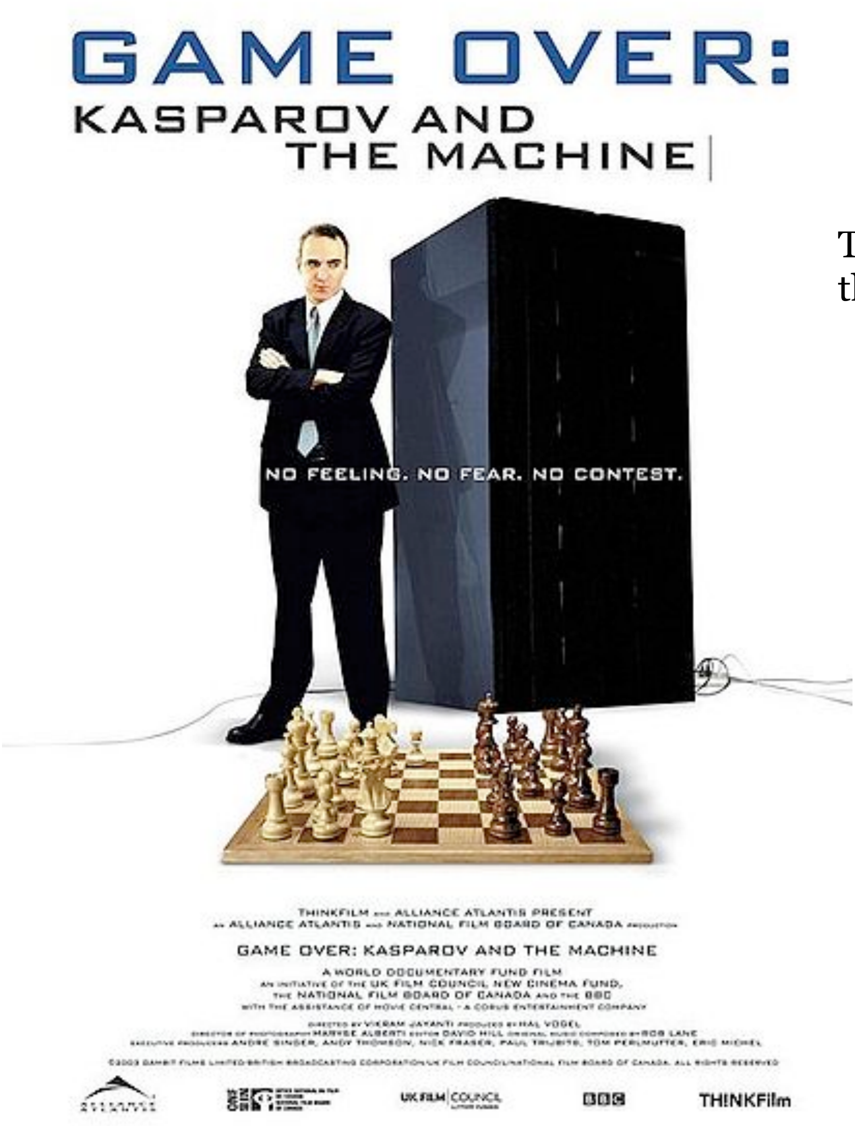
Brute force came into play in the early 70s as computers got faster.

Deep Thought is not at World Championship level. I defeated it twice in 1989!



Garry Kasparov, World Champion chess player (peak rating, 2851)

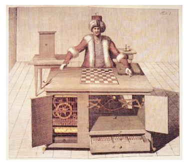
https://chessprogramming.wikispaces.com/Deep+Thought?f=print



The successor to *Deep Thought*, IBM's *Deep Blue,* defeated the reigning world champion, Kasparov $3\frac{1}{2}$-$2\frac{1}{2}$ in 1997.

Deep Blue's programming code is written in C and runs under the AIX operating system. The net result is a scalable, highly parallel system capable of calculating 100-200 billion moves within three minutes, which is the time allotted to each player's move in classical chess.*

If it took until 1997 for a computer to beat Kasparov, how did von Kempelen's *Turk* play such good chess?



* http://www.research.ibm.com/deepblue/

The chess playing automaton of von Kempelen was actually....

Plate 1.

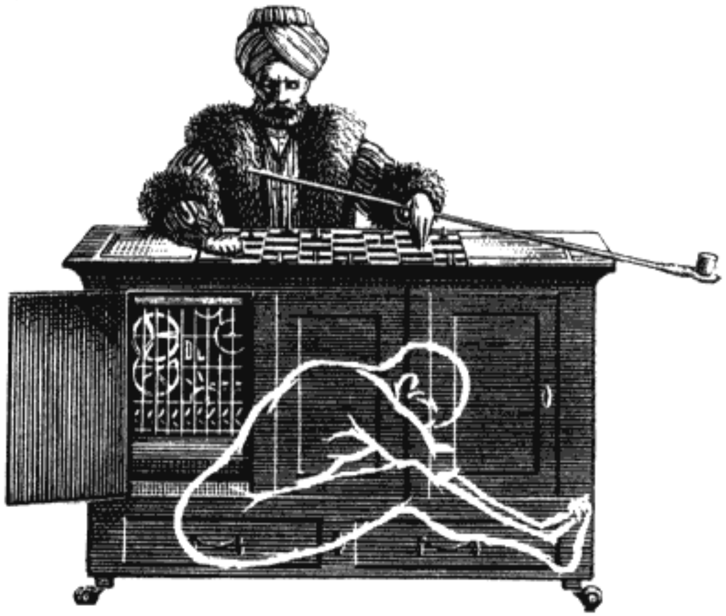


Plate 2.

Plate 3.

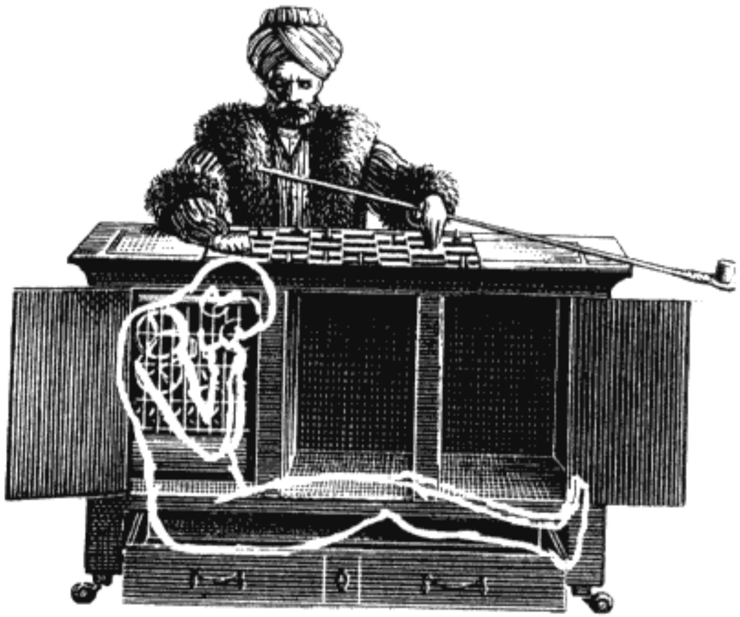
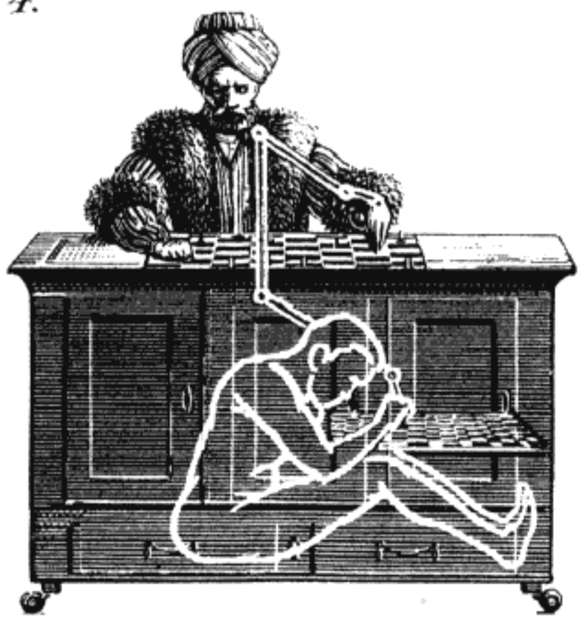


Plate 4.



...*a hoax*!

General Guan Yu (160–219) has his wounded arm treated by his physician while playing *Go*.

1853 Japanese woodblock print
Utagawa Kuniyoshi

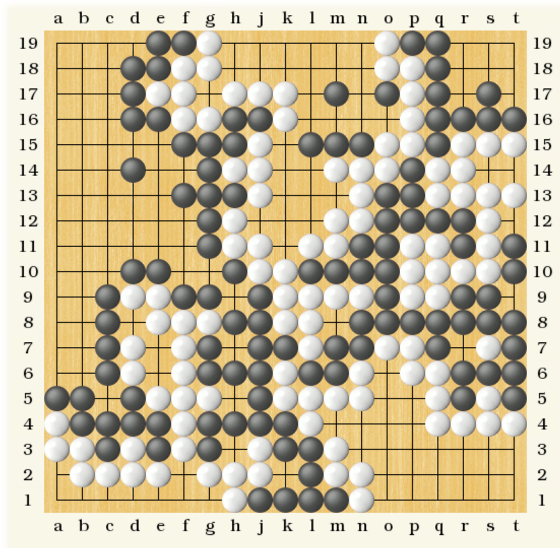
AI and Go

Computers have been less successful with the game of Go than with Chess.

Some reasons might include:

> Go starts with 55 possible moves on its symmetrical 19x19 grid. Chess begins with only 20.
>
> As the symmetry of the board is broken down, the number of possible Go moves *increases*.
>
> In many cases, as the game progresses, the Go board complexity increases whereas in a game like Chess pieces are removed for good, reducing complexity.

At what skill level is the current best Go program?



A game from Kevin Korb (he won as white)

The literate artificial, intelligent* character

In role playing games and third person shooters, the human adopts the persona of a virtual player, controlling its behaviour but not dictating what it can or cannot do... these constraints are set by the character itself, its "beliefs" and "abilities".

Ayumi, *X-Blades*
(Gaijin Entertainment, 2007+)

Chess is just not my thing...

Lara Croft, *Tomb Raider*
(Core Design, 1996+)

* The focus is not always on literacy or intelligence.

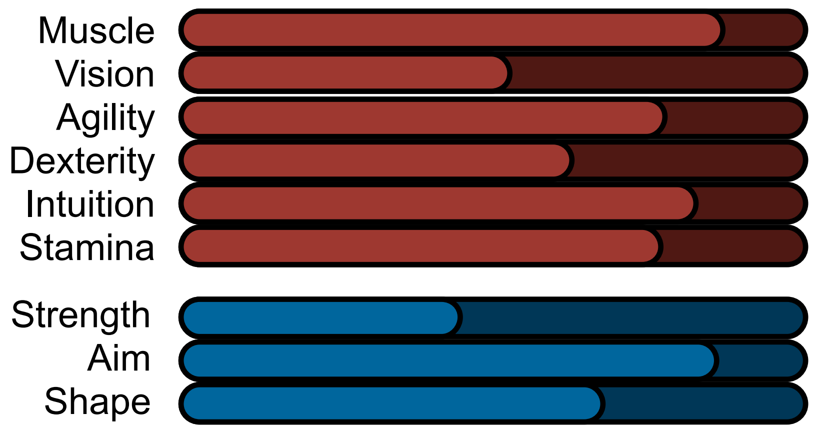
In a simple short term interaction there is often little effort made to learn about the player's tactics so reactive tactics are often sufficient to make game play interesting… room to improve!

Opponent agents can have different fighting styles, movements, weapons and abilities. They can react to you differently depending on your own avatar's features.

Soul Caliber (Namco, 1999+)

Opponent and human player attributes may be...

...a full set of independent attributes,



Depending on the game, these can all influence agent behaviour.

Street Fighter, Capcom 1987

2009

strip poker opponent - cards

table-tennis opponent - hand/eye coordination

ELIZA: Hello, I am Eliza.
ALAN: hello eliza
ELIZA: How are you today... What would you like to discuss?
ALAN: biscuits
ELIZA: Tell me more...
ALAN: I like biscuits
ELIZA: What does that suggest to you?
ALAN: nothing
ELIZA: Tell me more...
ALAN: what do you want to know?
ELIZA: We were discussing you, not me.
ALAN: Sorry.
ELIZA: Don't be so defensive!
ALAN >

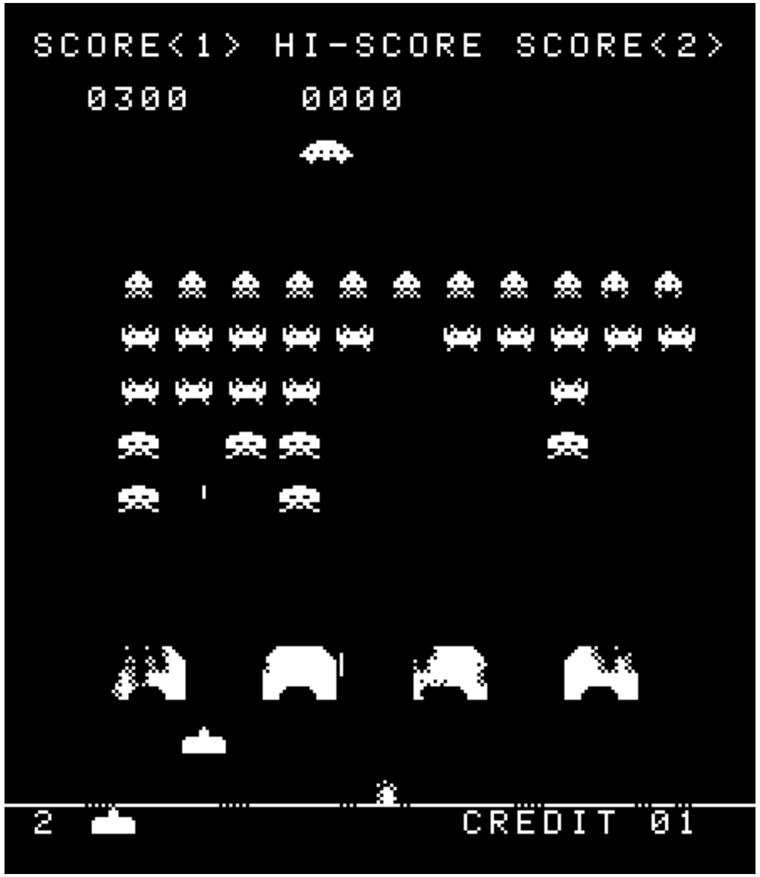
ELIZA (psychiatrist) - conversation / dialogue

In some games, the human player interacts from a first person perspective with a representation of intelligent life to build up a "relationship" that allows them to get to know the AI (rather than just killing them in a short exchange of gunfire or swordplay)

Multiple "Simple" Intelligent Agents

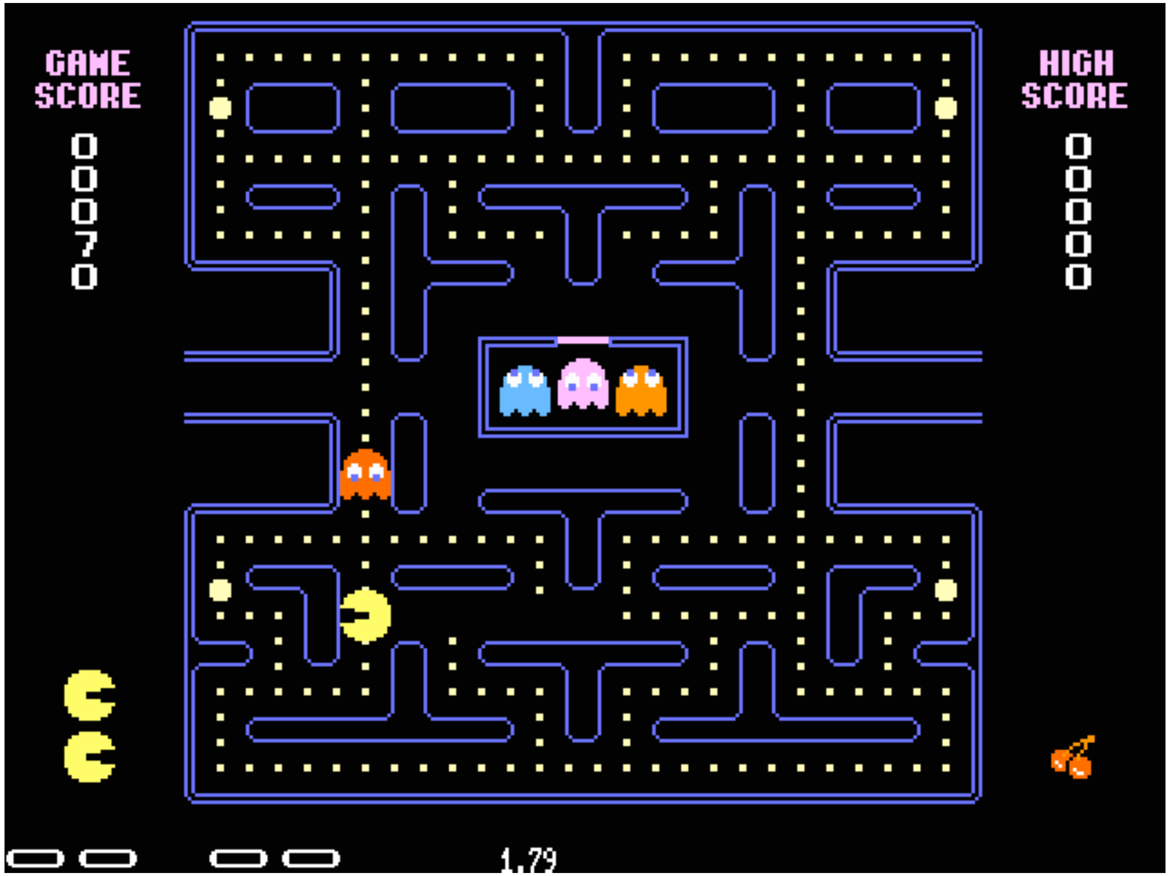
Often a human player interacts* with many simple life-like or intelligent, autonomous characters rather than with a single sophisticated agent or character.

Space Invaders (Tomohiro Nishikado, 1978)



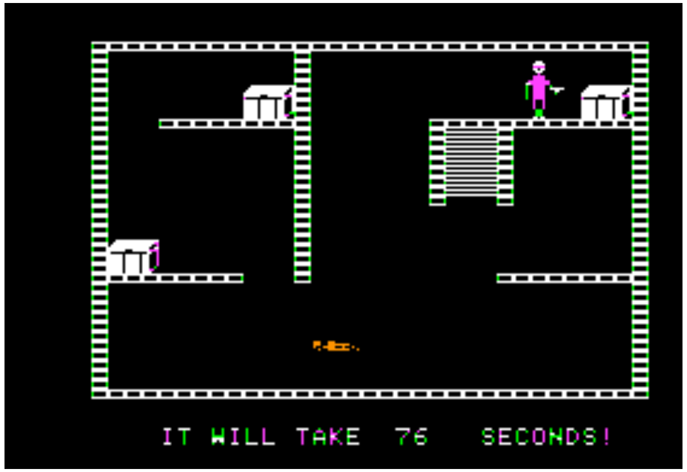
UFO and invaders move back and forth regularly across the the screen...
...not very intelligent but a lot of fun!

Pacman (Namco, 1980)



Ghosts move according to their own "character" giving them the appearance of at least some intelligence and uniqueness.

* destroys



Castle Wolfenstein
(Apple II version, Muse Software, 1981)

Wolfenstein 3D (idSoftware, 1992)

Doom (idSoftware, 1993+)

First Person Shooters

The AI of characters being shot at gradually increased during the 80s, 90s and beyond. As graphic capabilities increased, 3D virtual environments became common and agents needed to be able to do the following in three dimensions:

- Navigate
- Shoot accurately
- Take cover
- Collaborate (e.g. move and attack as a group)
- Anticipate motion (e.g. of bullets)

Quake (idSoftware, 1996+)

Realtime Strategy Games

Realtime strategy games like *Age of Empires* pit the human against a virtual player (as in Chess or Go).

Both the human and virtual player direct simple agents in a virtual world to carry out tasks such as gathering resources, fighting, construction work etc.

Command & Conquer (Westwood, 1995+)

Black and White (Lionhead, 2001+)

Age of Empires (Ensemble Studios, 1997+)

What AI might RTS agents exhibit?

Agents from *Age of Empires*
(Ensemble Studios / Microsoft, 1997+)

Moving from A to B:

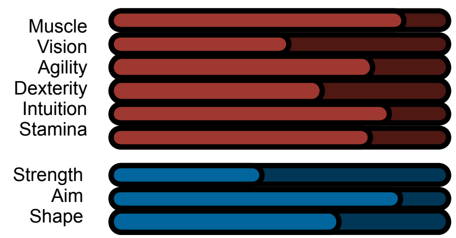
- avoiding static obstacles
- following a road or route
- maintaining separation from one another
- tracking a target
- fleeing an enemy

Interactions with a human player:

- falling in love or picking a fight
- trading goods, driving a hard bargain or offering a discount
- laughing at their antics or turning away in scorn

Fable II (RPG) character's traits emerge over time as the player makes decisions during the game... a life-like way of handling trait selection that reduces the need for pre-defined character determination.

Fable (Lionhead/Microsoft, 2008+)



With more complex characters we're moving on...

Game AI replicating modern human society…
SimCity and *The Sims*

…players can now see their Sims age from cradle to grave, pass on traits to their children and learn how events in childhood can affect a Sim in later life.

> "One of the first things people generally do with the game is to put themselves into it, maybe their family, their wife, their neighbours, their house," Wright says. "As you are playing you are, from the Sims' point of view, balancing all these factors in their little life: work, family, kids and all that; and you can't help, as you play the game for a little while, but start developing a deeper awareness of your own life."

- *Sydney Morning Herald*, "Sims Like Us" by Tristan Davies, Dec. 18, 2004*

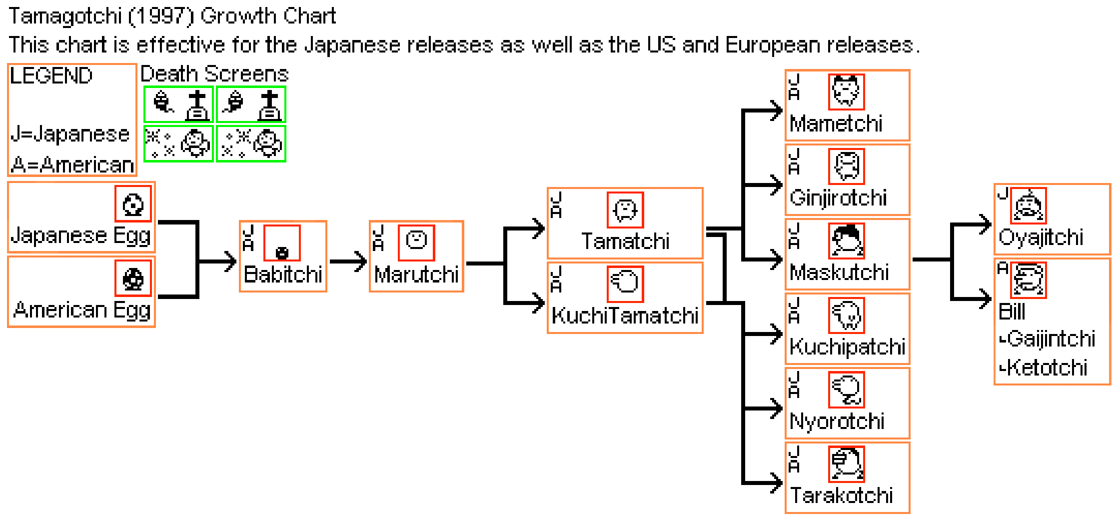
Sim City – Classic version, 1989+

The Sims (Maxis/EA, 2000+)

* http://www.smh.com.au/news/Technology/Sims-like-us/2004/12/17/1102787274524.html

Virtual Pets

Tamagotchi (Aki Maita/Bandai, 1996)



Tamagotchi growth chart by OsuMesu21, 1997

Grendel

Norn

We have our own "biochemistry" that controls our emotions and behaviour. You can feed us, heal us, discipline us... even torture us!

Creatures (Creature Labs, 1996+)

Procedural Virtual Environments

Will Wright, of *Sims* fame, designed *Spore*…

…but players build *Spore*’s creatures by starting with a microbe and leading it into an advanced species capable of inter-galactic colonisation.

Procedural software generates *Spore*’s creatures and environments from a simple set of parameters analogous to the DNA of an organism.

Spore creature creator (Maxis, 2008)

Spore (Maxis, 2008)

*NB Spore is *not* a scientifically accurate portrayal of the evolution of life!

Natural language processing, interactive adventure and fiction

ELIZA: Hello, I am Eliza.
ALAN: hello eliza
ELIZA: How are you today... What would you like to discuss?
ALAN: biscuits
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ELIZA: Don't be so defensive!
ALAN >

ELIZA
(Joseph Weizenbaum, 1966)

Leisure Suit Larry (Sierra On-Line, 198x?)

Conquests of the Longbow (Sierra On-Line, 1992)

```
>look
Kitchen
You are in the kitchen of the white house. A table seems to have been
used recently for the preparation of food. A passage leads to the west
and a dark staircase can be seen leading upward. A dark chimney leads
down and to the east is a small window which is open.

>look at passage
There's nothing special about the way.

>look in chimney
You can't look inside a chimney.

>go up stairs
You have moved into a dark place.
It is pitch black. You are likely to be eaten by a grue.

>use lantern
I don't know the word "use".

>light lantern
The brass lantern is now on.

Attic
This is the attic. The only exit is a stairway leading down.
A large coil of rope is lying in the corner.
On a table is a nasty-looking knife.

>
```

Zork
(Tim Anderson et al./Infocom 1977-79)

(Text parsing in Zork was better than many later games...
"climb the large tree" is an improvement over "climb tree")

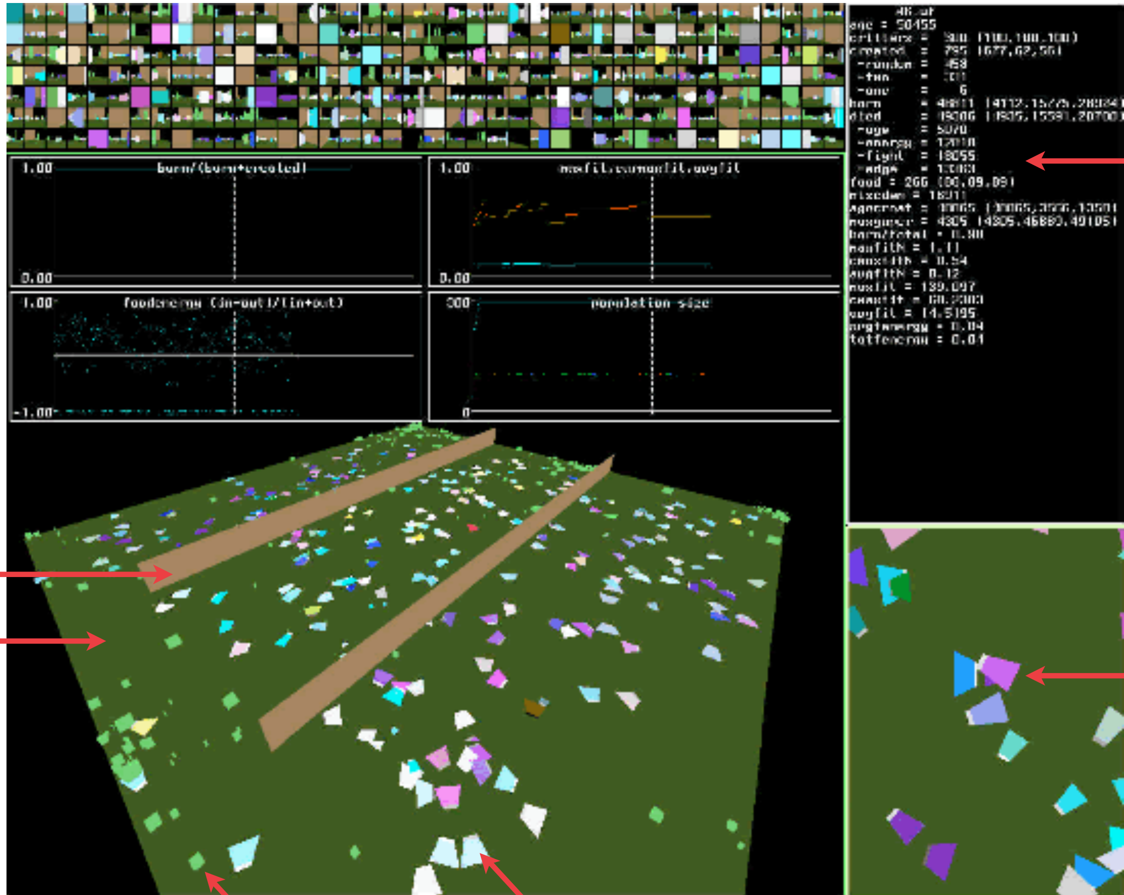
Cinema special effects (crowds)

As can be seen in this Battle of Helm's Deep (*Lord of the Rings: The Two Towers*, P. Jackson 2002), virtual agents with intelligent, life-like behaviour can work in complex virtual environments to great cinematic effect!

Polyworld, an evolving virtual ecosystem by Larry Yaeger

PolyWorld agents have neural-network brains and colour visual systems. They mate, eat, fight, move and turn. But they aren't pretty (to our eyes anyway). Agents and environments needn't be pretty, or even visualised, to be useful.

What are they good for? What traits do they need?



diagnostic data about the world's state etc.

impassible barrier

ground plane (table top)

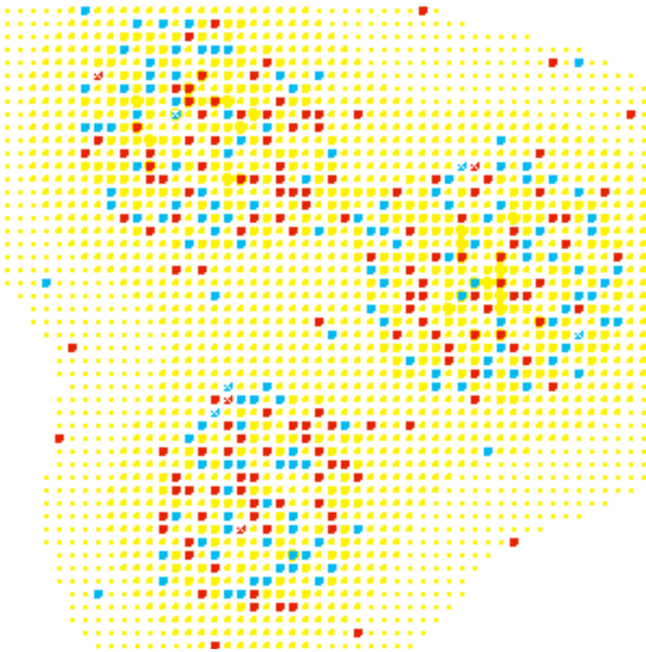
detailed view showing different coloured agent body parts

food (green polygons)

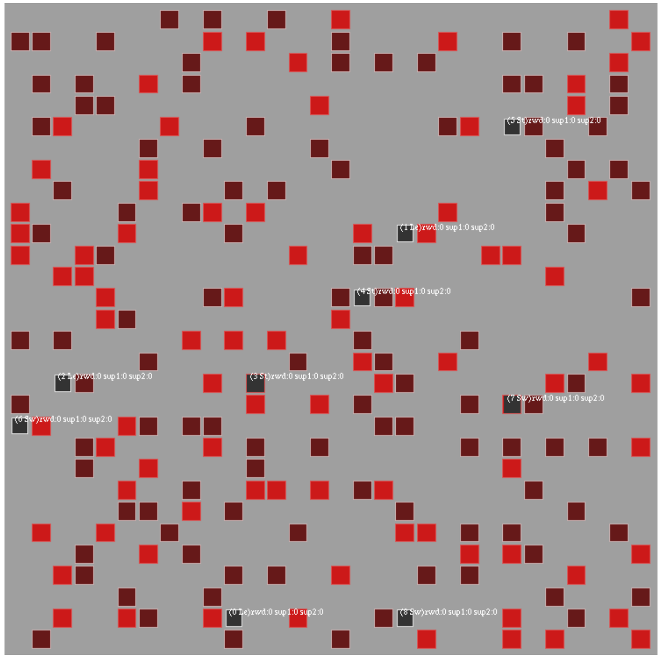
agents (coloured polygons)

Yaeger, L. (1992). Computational Genetics, Physiology, Metabolism, Neural Systems, Learning, Vision and Behavior or Polyworld: Life in a New Context. *Artificial Life III*. C. Langton, Addison-Wesley: 263-298.

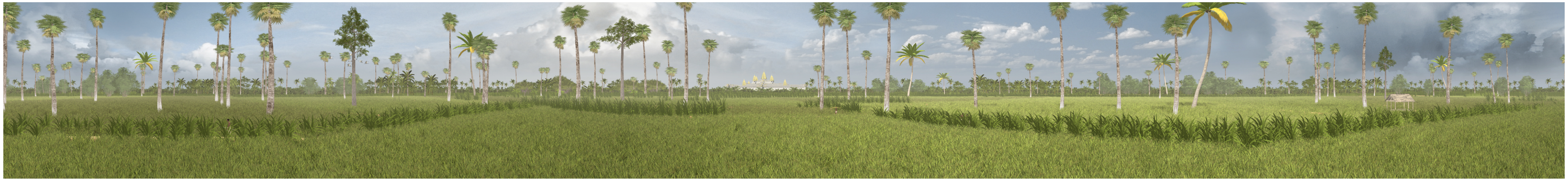
How does Science apply intelligent, life-like agents and virtual environments?

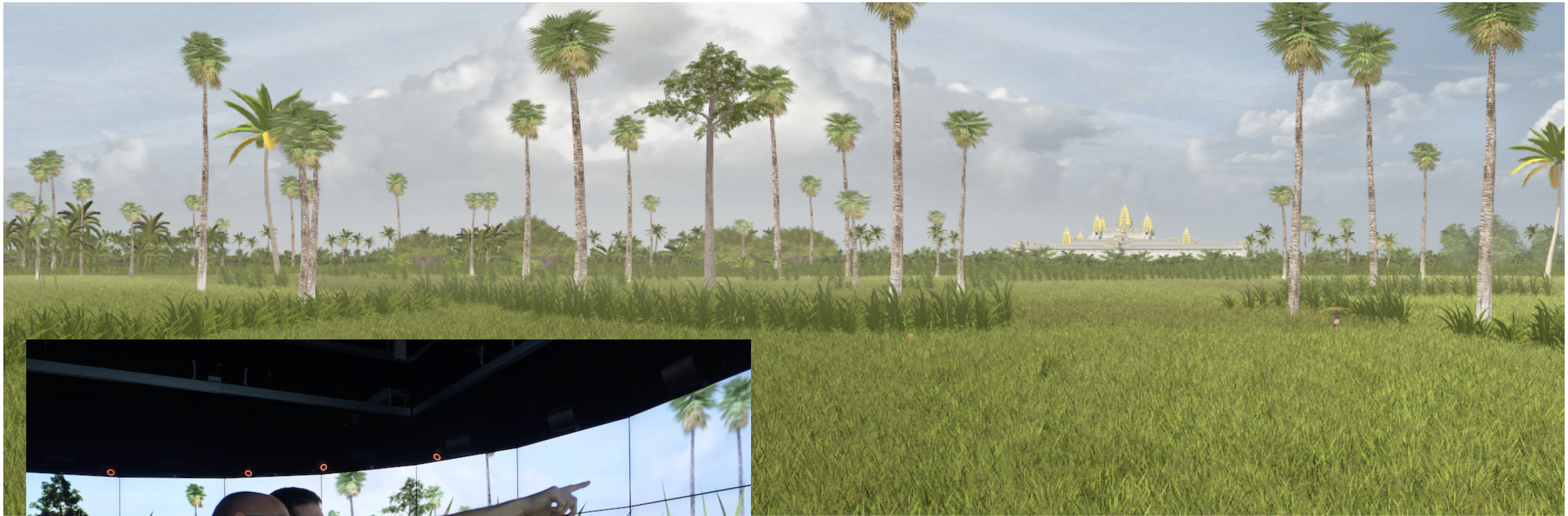


Epstein and Axtell, *Sugarscape 1996*

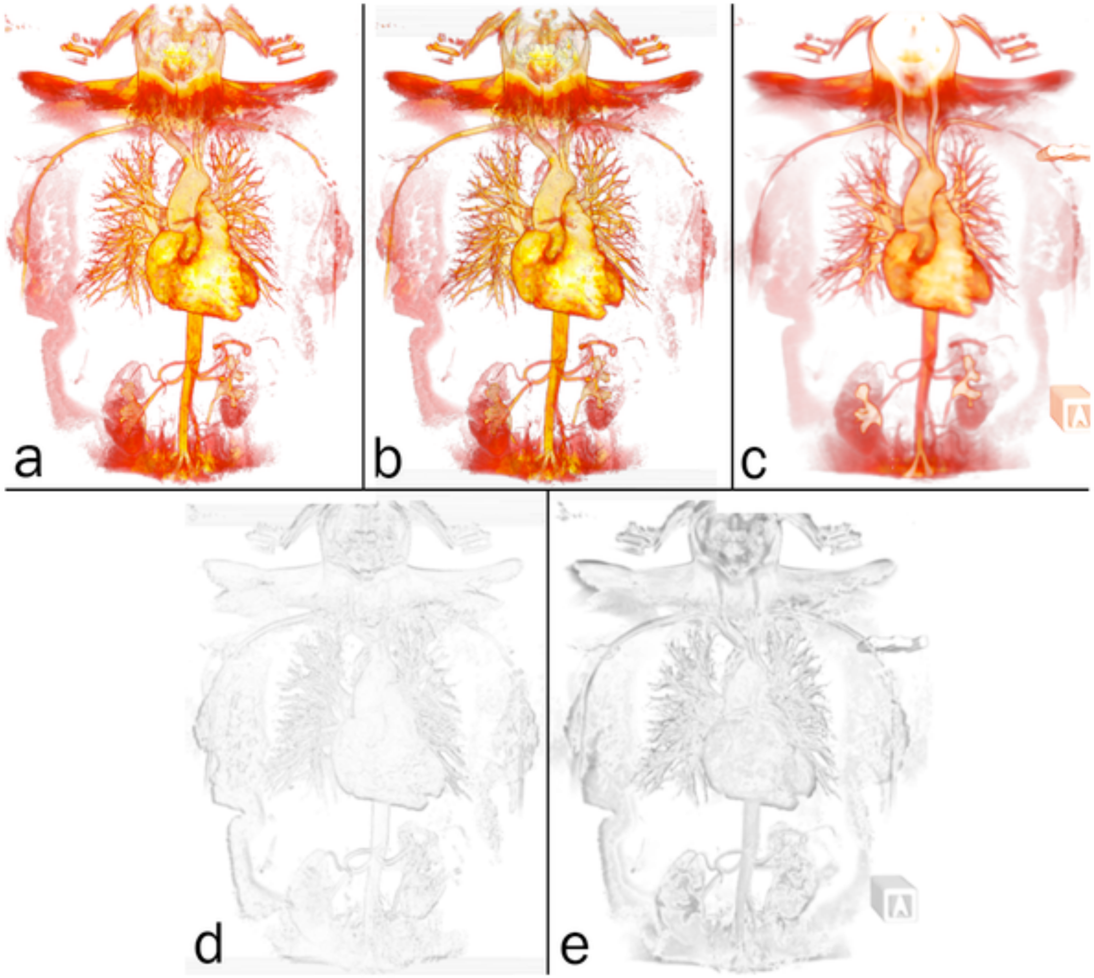


Dorin, Dyer, *Bees* 2012





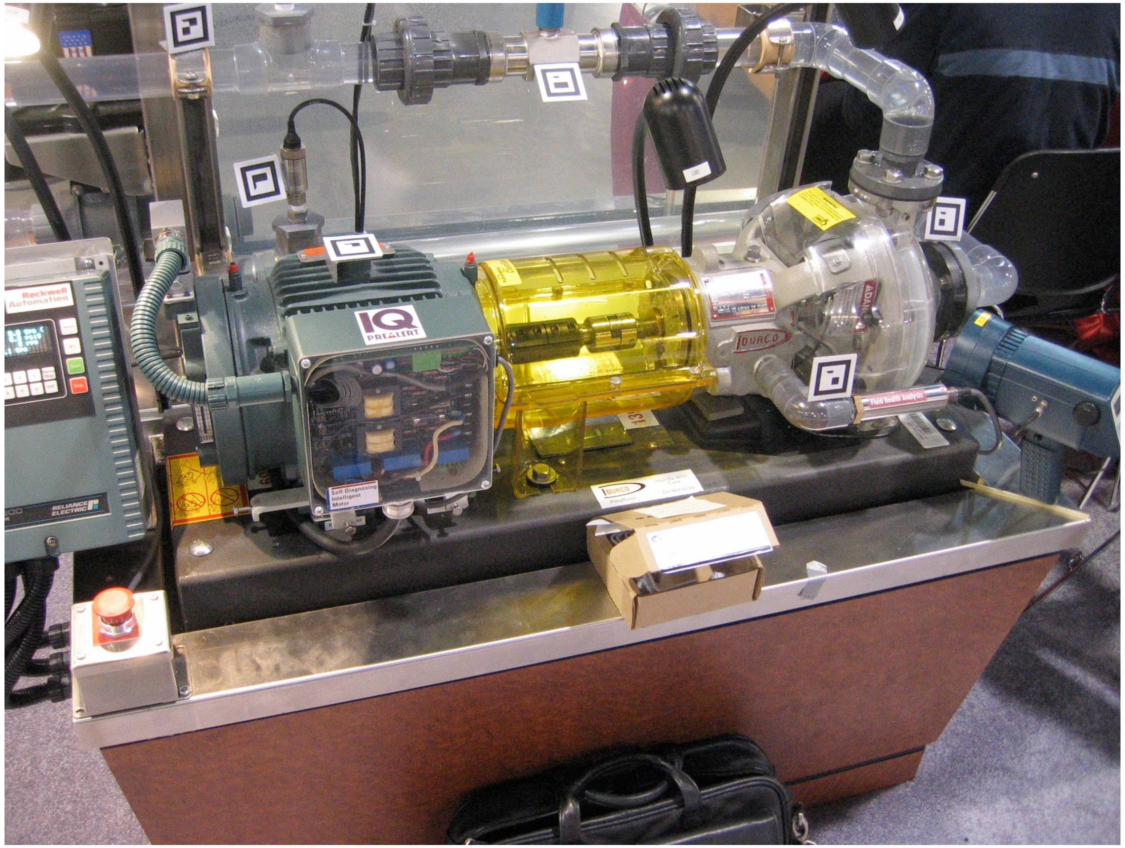
Digital Heritage / Visualisation



Scientific Data Visualisation.

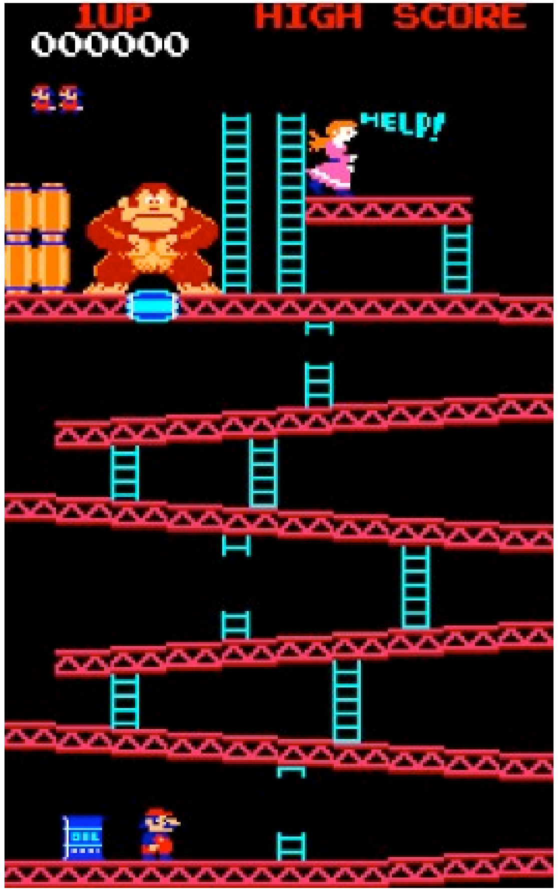
Not real “places” but virtual environments all the same

Interactive Training in completely virtual reality, or with augmented reality.



Flight Simulator Boeing, Thetis Games - October 4, 2013

F. Discenzo, D. Chung, D. Carnahan, S. Chen, R. Behringer, V. Sundareswaran, K. Wang, J. Molineros, J. McGee. Augmented Reality Supports Real-time Diagnosis and Repair of Complex Shipboard Systems. IFAC Conference on Control Applications in Marine Systems. Ancona, July 7-9, 2004.



Donkey Kong (Nintendo 1981)

Intelligent, life-like agent properties (summary)

- Be **responsive** to change in the environment (and a human player).
- Autonomously **solve problems**: dodge falling objects, plan routes, avoid predators and execute a series of connected actions to achieve goals.
- Demonstrate variable, appropriate and **diverse autonomous behaviour**.
- **Anticipate** future events: intercept prey, activate devices to reach goals.

For game-play: Be intelligent and interesting but not *too* skillful!

For science: Behave like real organisms in *relevant* ways.

...note that *some* virtual environments have no active agents.