

# **Inteligência Artificial aplicada a Jogos Digitais**

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# CRAb

Computação Gráfica, Realidade Virtual, Animação e  
Visualização Científica

## Deep Reinforcement Learning para Jogos

Deep Learning + Aprendizado por Reforço



UNIVERSIDADE  
FEDERAL DO CEARÁ

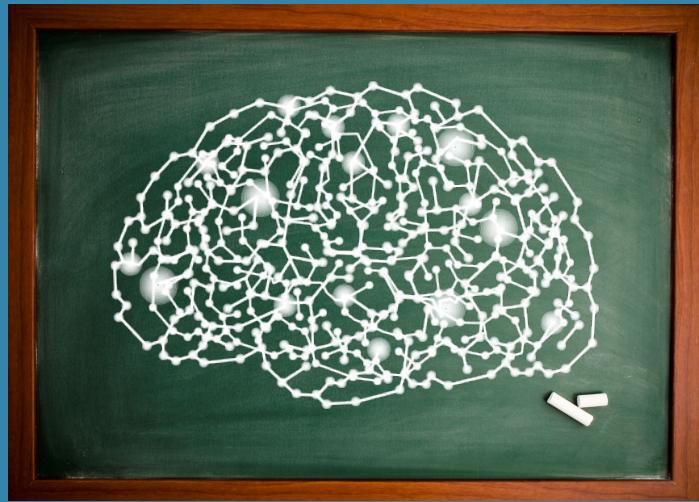


COMPUTER GRAPHICS VIRTUAL REALITY AND ANIMATION

# MINHA PESQUISA

[youtu.be/JTNZCX01r2Y](https://youtu.be/JTNZCX01r2Y)

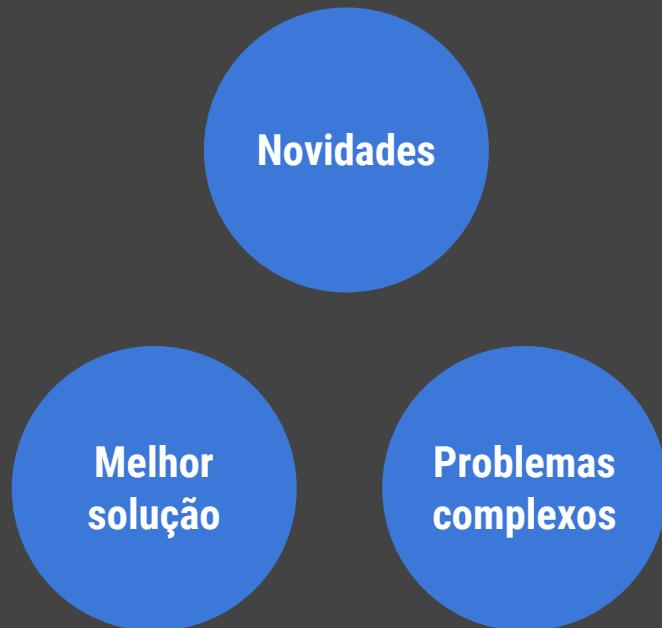




VS



# Academia

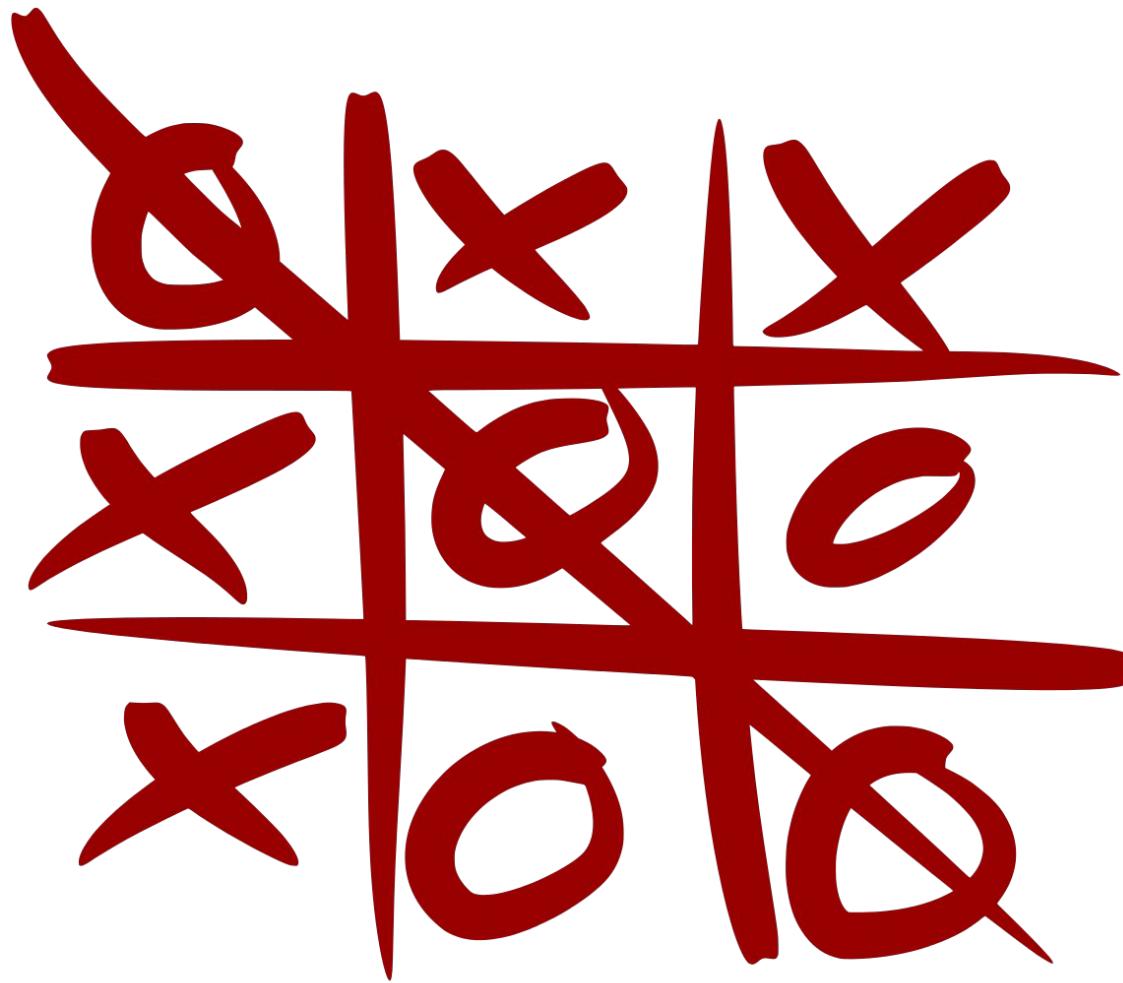


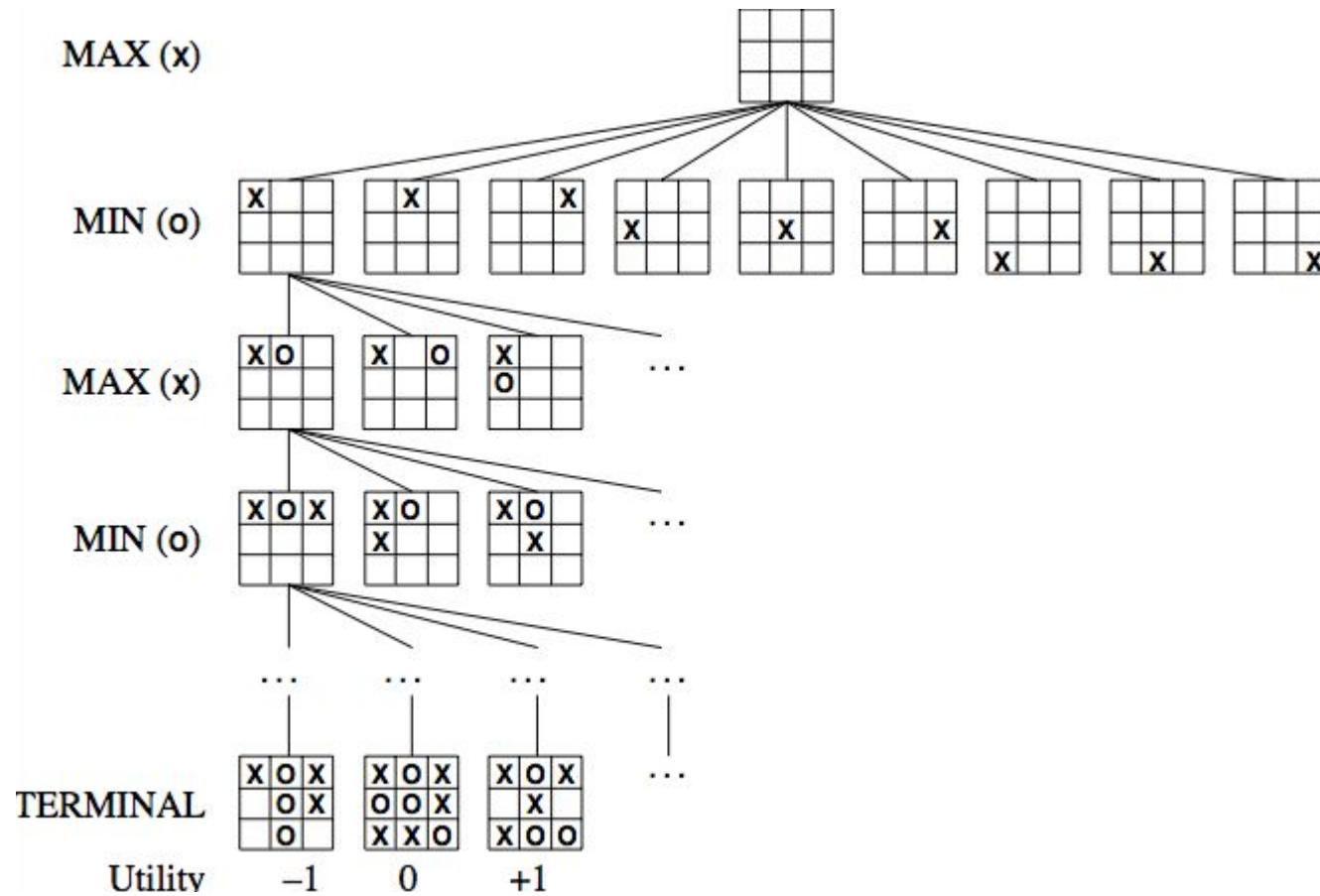
# Indústria



A man with dark, curly hair and a beard is shown from the side, leaning over a chessboard. He is wearing a dark suit jacket. His reflection is visible in the mirror behind him, creating a symmetrical scene. The chessboard is made of wood and is set up with pieces. The background is a plain, light-colored wall.

*Jogos de tabuleiro*









**Chinook (Jonathan Schaeffer) vs Marion Tinsley (1994)**

Silicon Graphics





GM Kasparov 2.5 vs 3.5 Deep Blue (1997)



Komodo Chess Engine 2.5 x 1.5 GM Nakamura (2016)





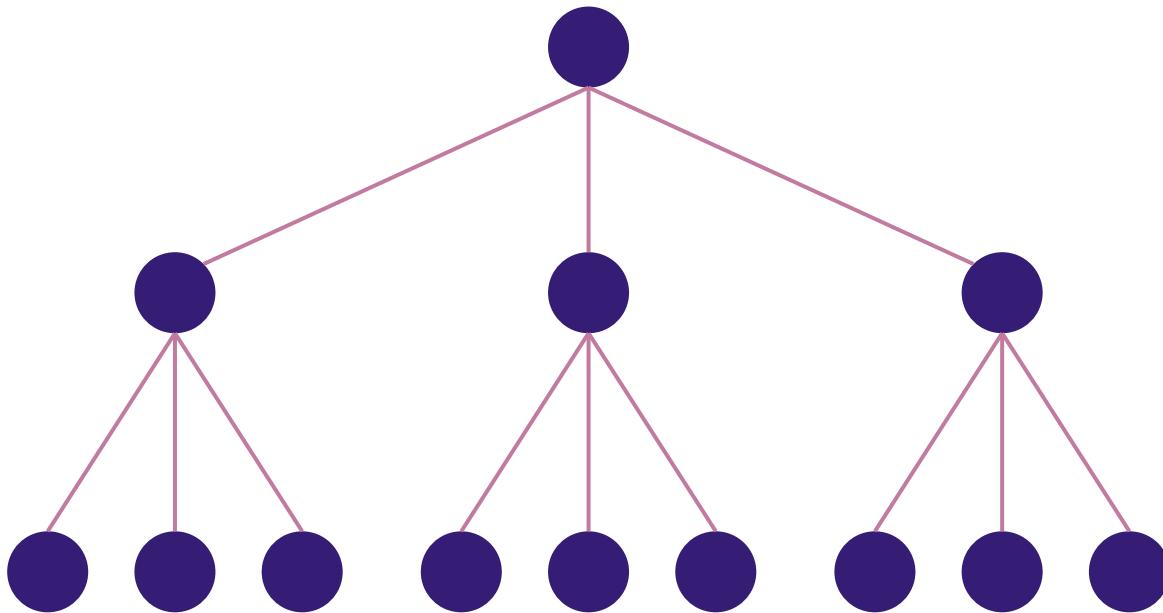
AlphaGo

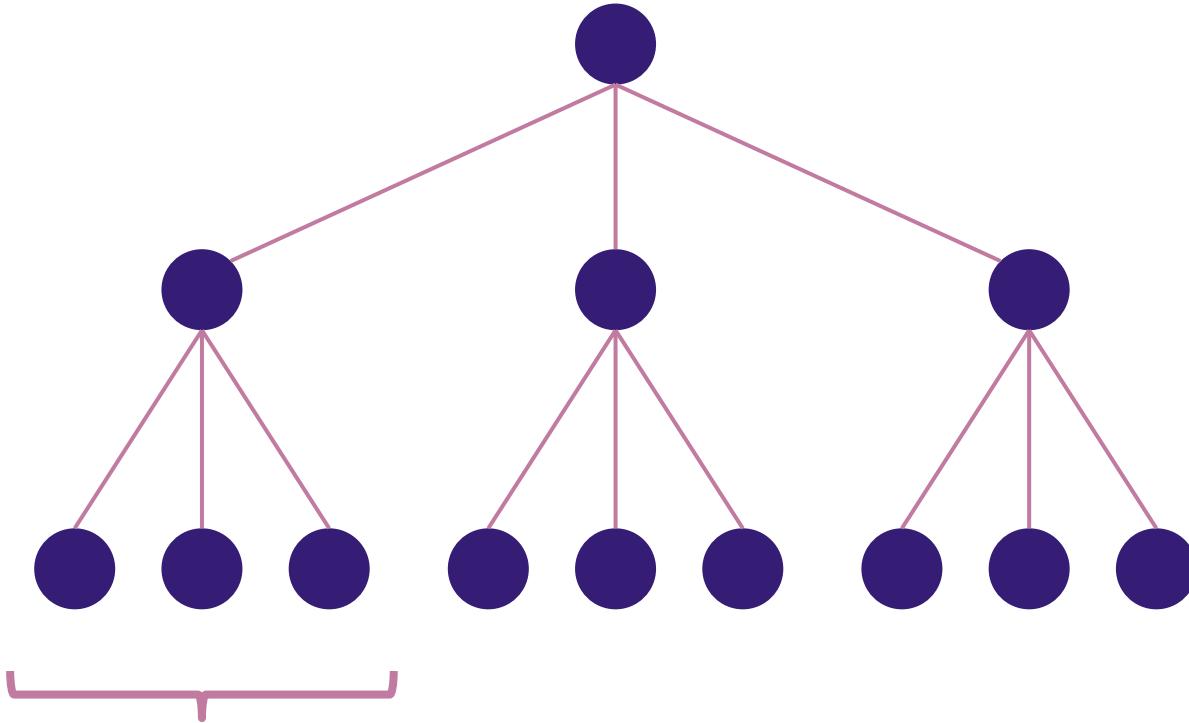


Lee Sedol

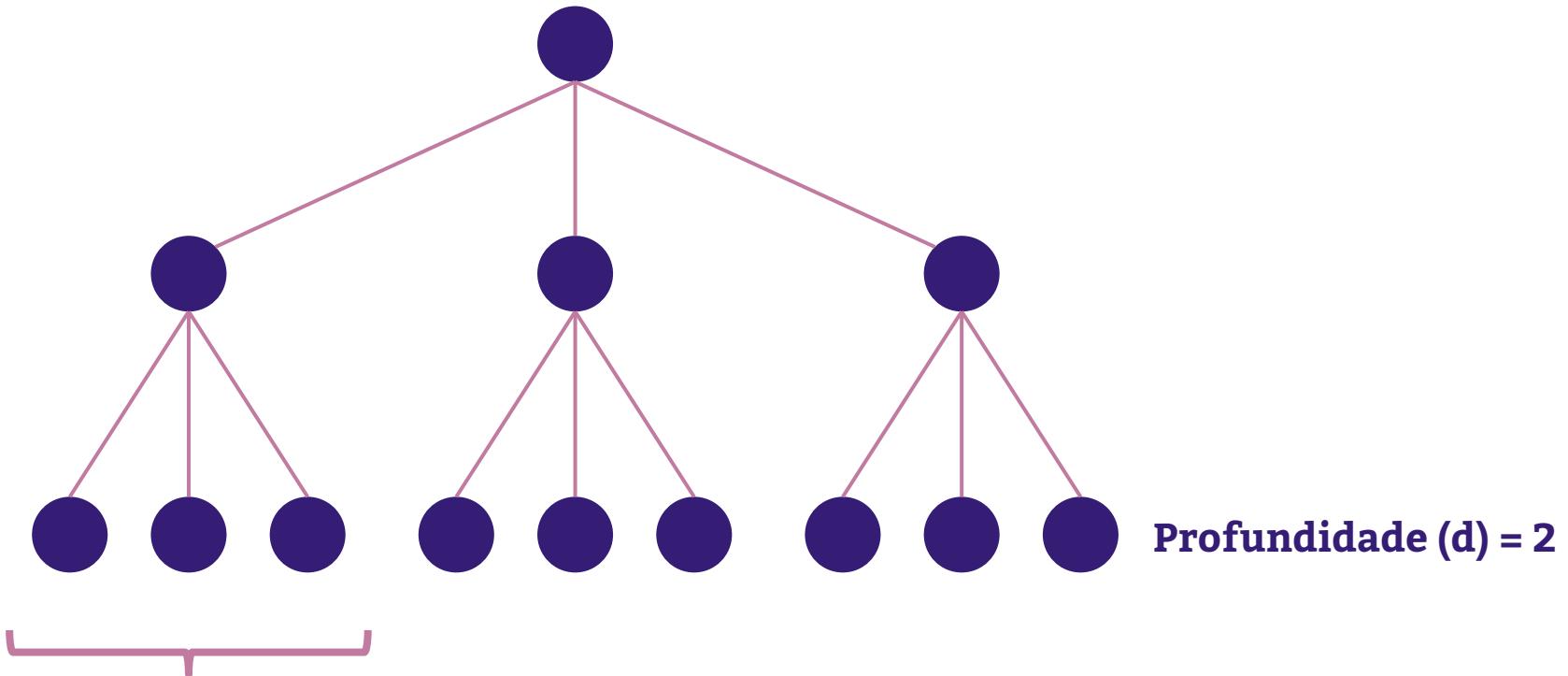


AlphaGo 4 vs 1 Lee Sedol



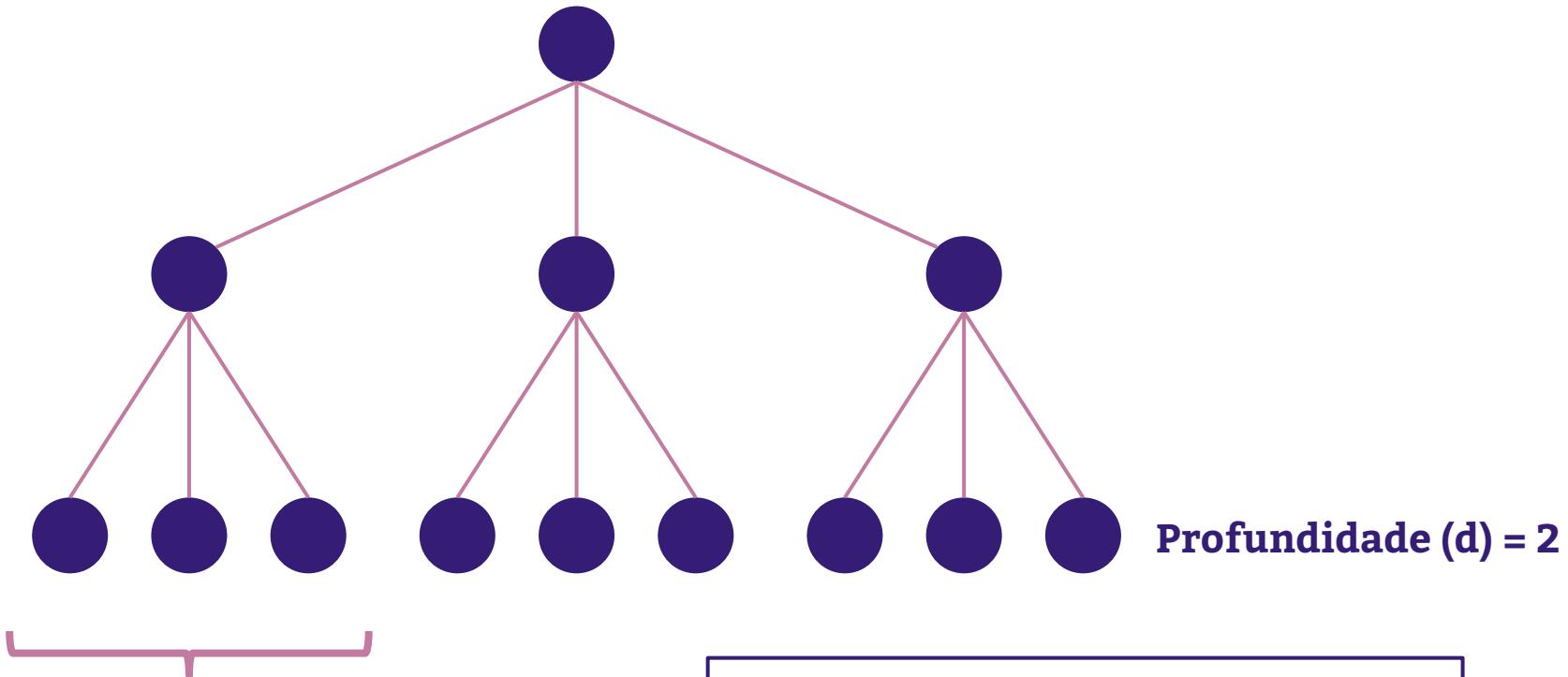


**Fator de ramificação (b) = 3**



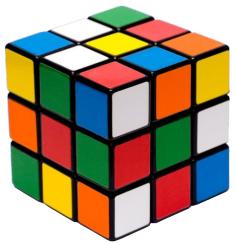
**Fator de ramificação (b) = 3**

**Profundidade (d) = 2**



Fator de ramificação (b) = 3

Complexidade em  
relação ao tempo =  $O(b^d)$



**b = ~13.34**

**d = ~18**

**Espaço de busca = ~ $10^{19}$**



**b = ~35**

**d = ~100**

**Espaço de busca = ~ $10^{120}$**



**b = ~300**

**d = ~150**

**Espaço de busca = ~ $10^{360}$**



**b = ~ $10^{100}$**

**d = ?**

**Espaço de busca = ???**

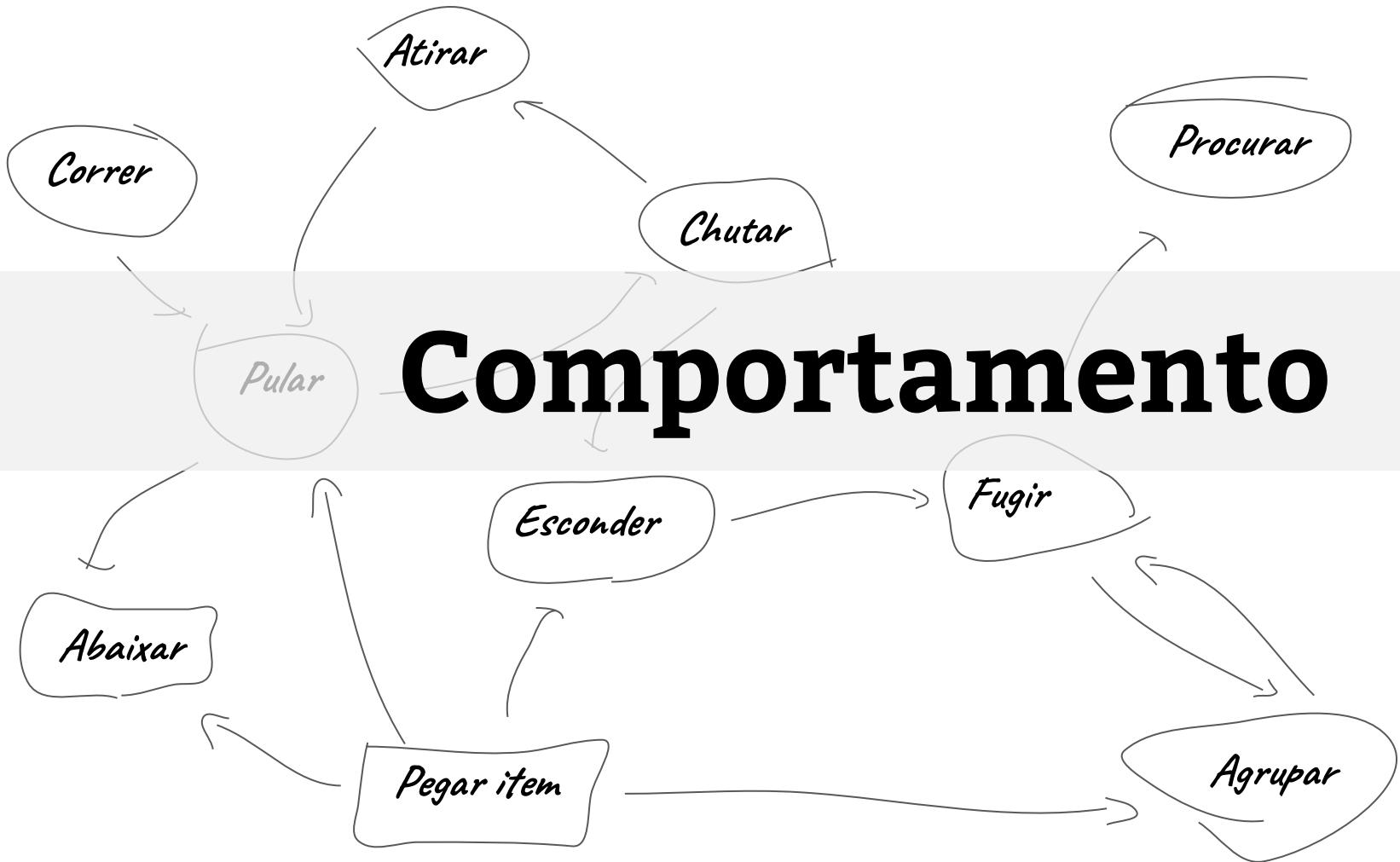


O que é  
**inteligência  
Artificial**  
para  
**JOGOS?**

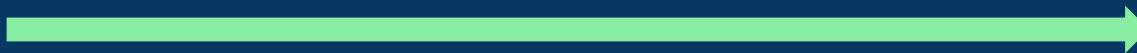
(comerciais)



# Comportamento



↑  
c  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e



Dificuldade

↑  
C  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e



Fácil

↑  
C  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e



Fácil

↑  
c  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e

Fácil



Difícil



↑  
C  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e

Fácil



Difícil











**Headshot = 1/3**



↑  
C  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e

Fácil



Difícil



↑  
c  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e

Fácil

Ideal

Difícil



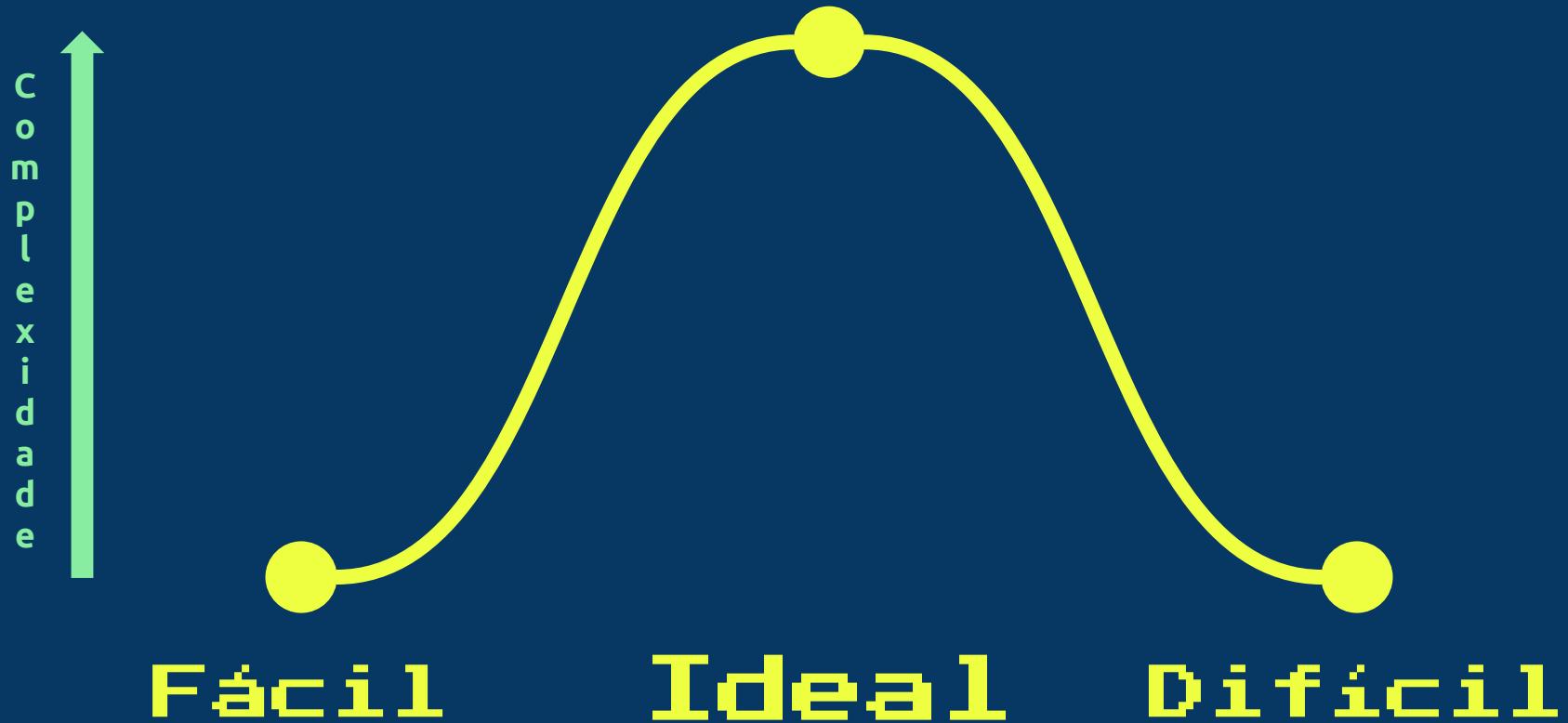
↑  
c  
o  
m  
p  
l  
e  
x  
i  
d  
a  
d  
e

Fácil

Ideal

Difícil





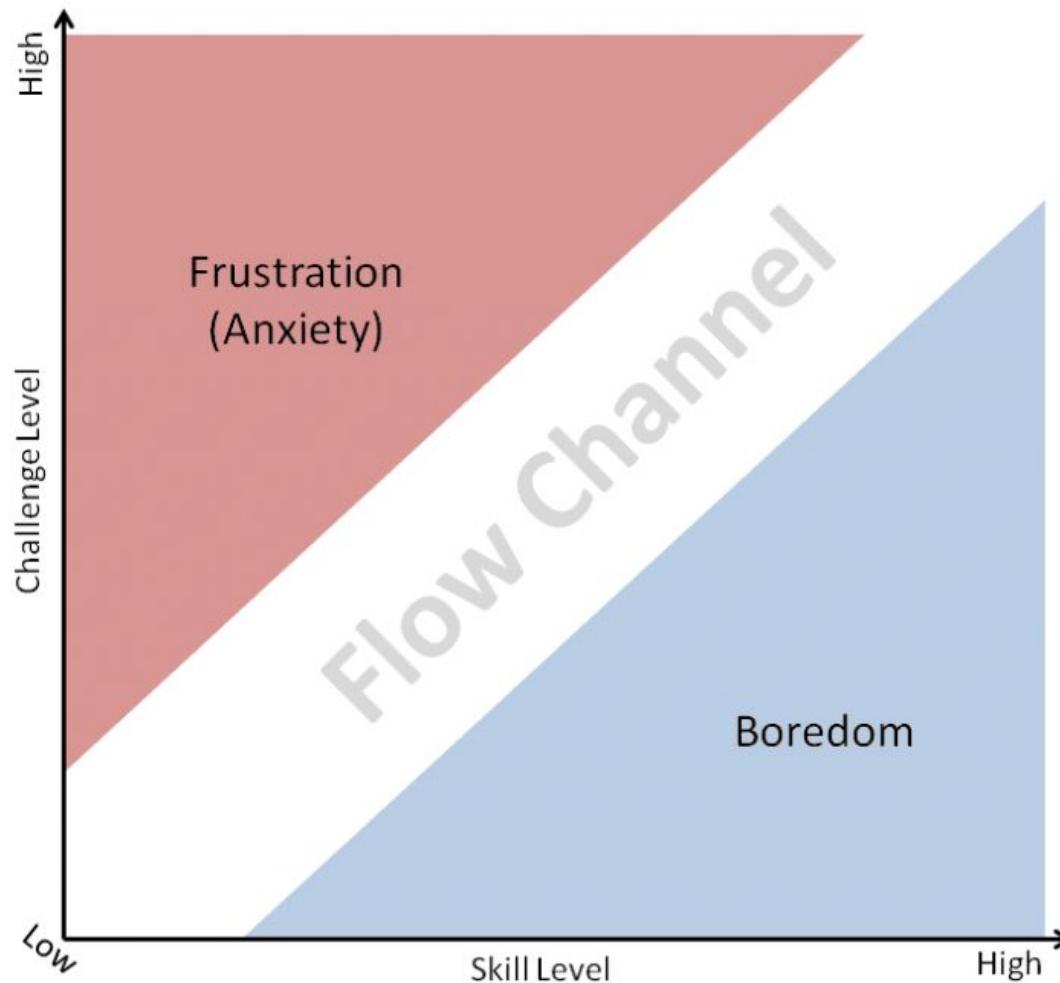
↑  
C  
o  
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p  
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e  
x  
i  
d  
a  
d  
e

pode ser  
"burro"

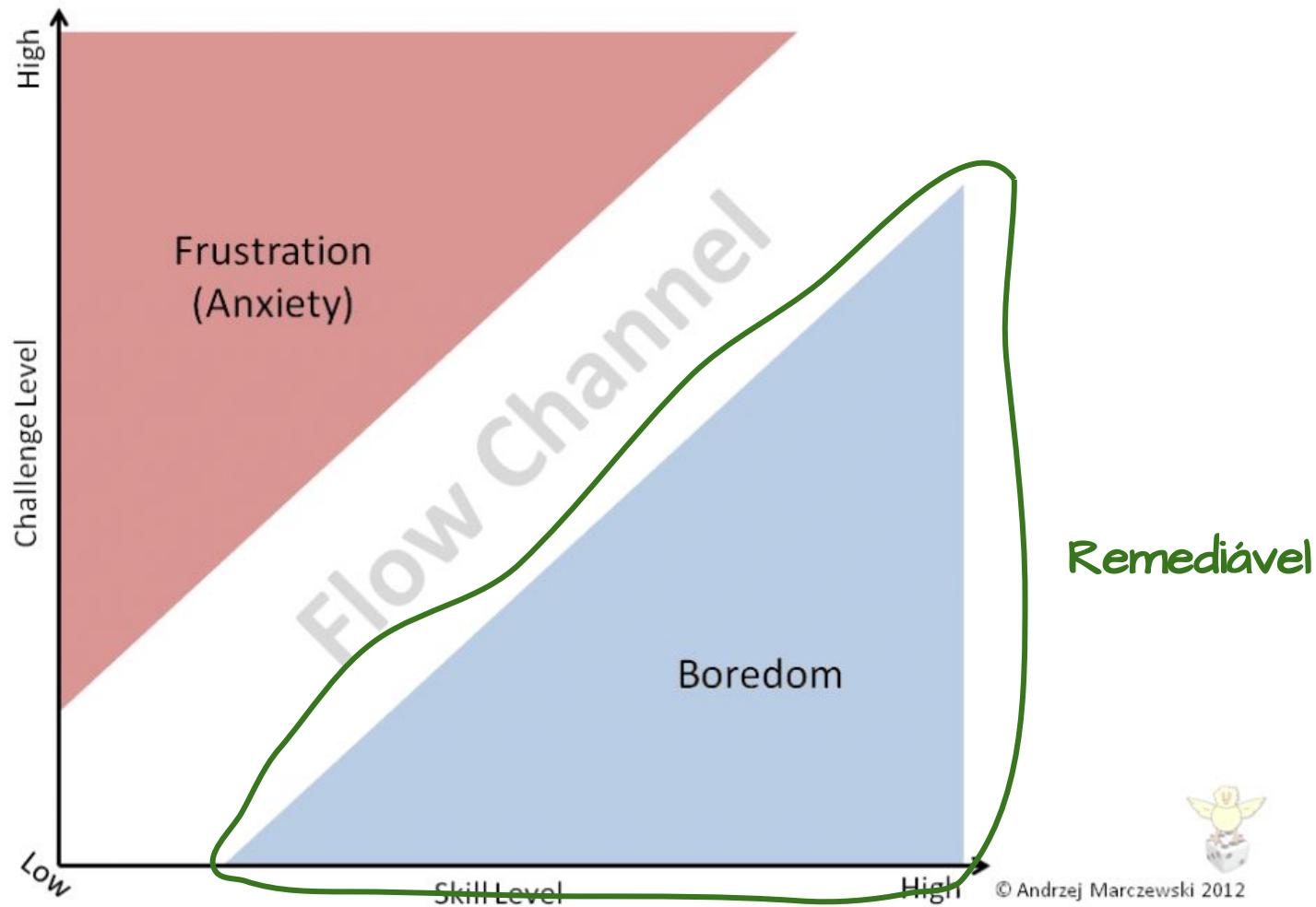
**Fácil      Ideal      Difícil**

pode ser  
"roubado"

# Flow Simplified

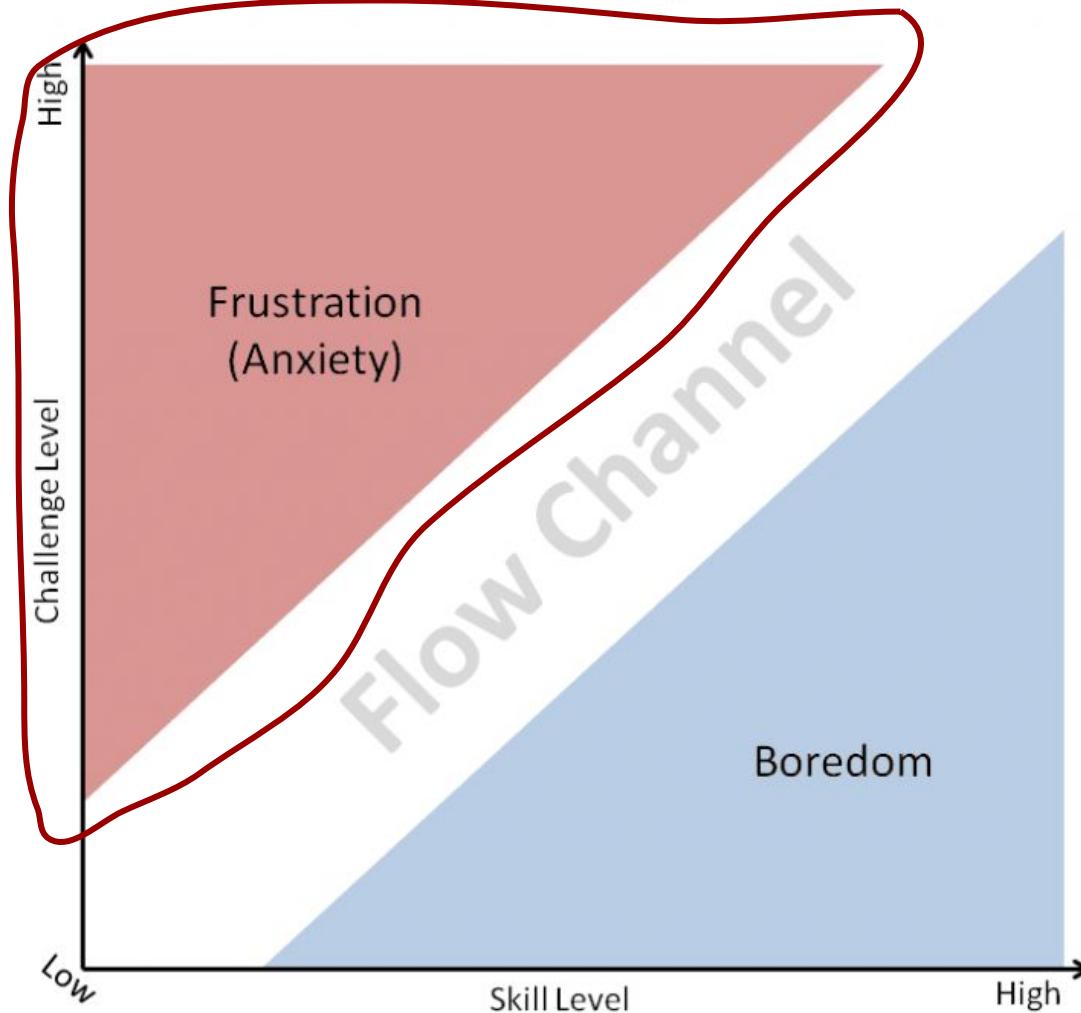


# Flow Simplified



# Flow Simplified

Morte  
do jogo



“Boa o suficiente para ser desafiadora,  
Ruim o suficiente para ser divertida”.

**60** Frames  
Per  
Second

**60** Frames  
Per  
Second

**60**

**Frames  
Per  
Second**

=  $\frac{60 \text{ frames}}{1 \text{ segundo}}$

**1** segundo

**1000** milissegundos



x 

---

**60** frames

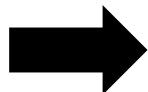
**1** segundo

$$\frac{1 \text{ segundo}}{60 \text{ frames}} \times 1000 \text{ milissegundos} = \frac{1 \text{ segundo}}{1 \text{ segundo}}$$

**1**  
**frame** →

**1000** milissegundos  
—  
**60** frames

**1**



**16.7**

**frame**

**milissegundos**

Input

IA

Física

Renderização

The diagram illustrates a complex system flow, likely representing a game engine's physics and rendering pipeline. It features several overlapping and interconnected components:

- Input**: Represented by large, semi-transparent text labels.
- Physics**: Represented by large, semi-transparent text labels.
- Renderization**: Represented by large, semi-transparent text labels.
- IA**: Represented by smaller, semi-transparent text labels.

The flow is depicted as follows:

- Input** feeds into **Physics**.
- Physics** feeds into **Renderization**.
- Renderization** feeds back into **Input**.
- Input** also feeds into **IA**.
- IA** feeds into **Renderization**.
- Renderization** feeds back into **Physics**.
- Physics** feeds back into **Input**.

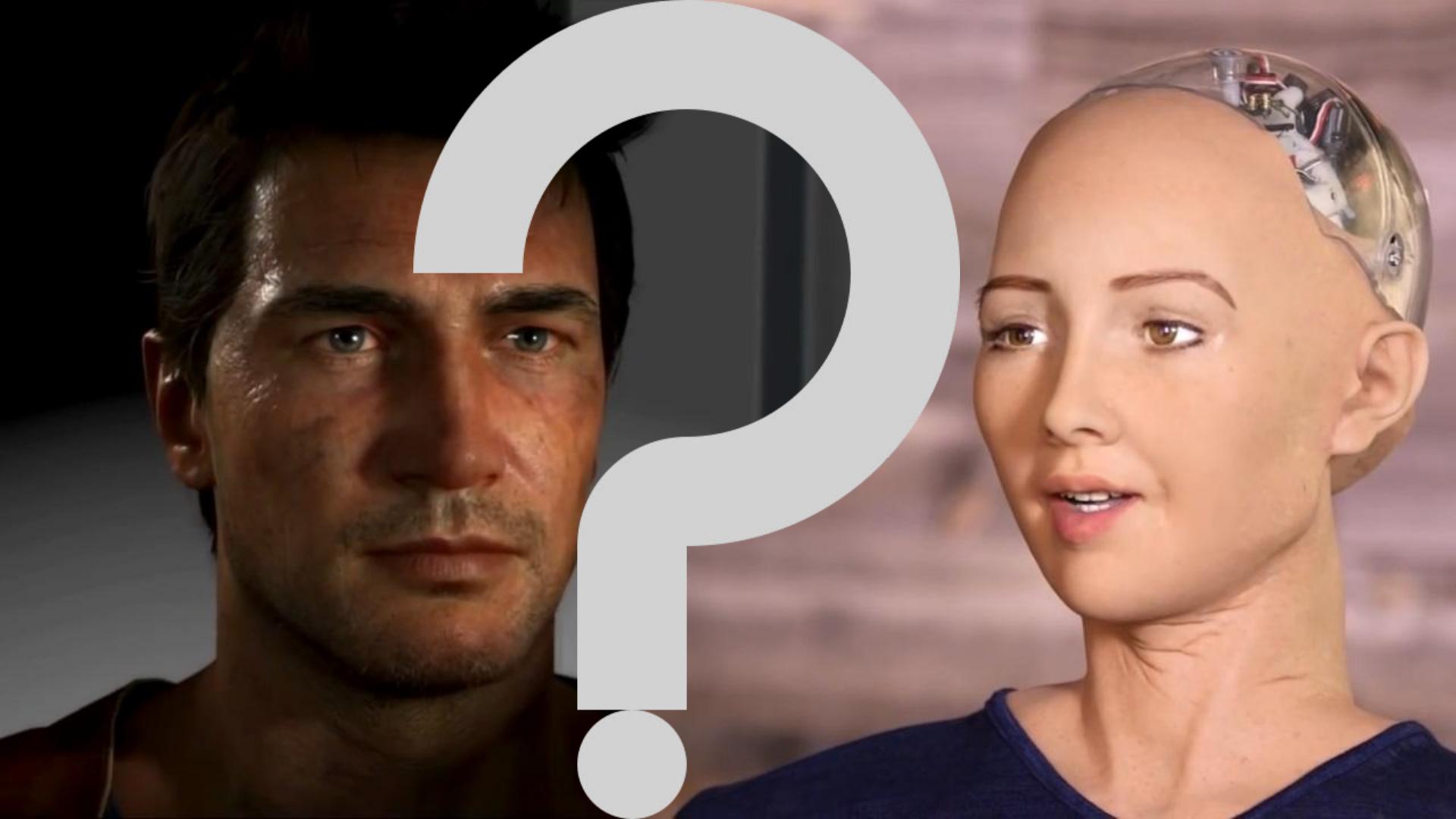
The labels are rendered in a light gray color, creating a semi-transparent effect where they overlap. The overall layout is dynamic and circular, emphasizing the continuous interaction between these components.

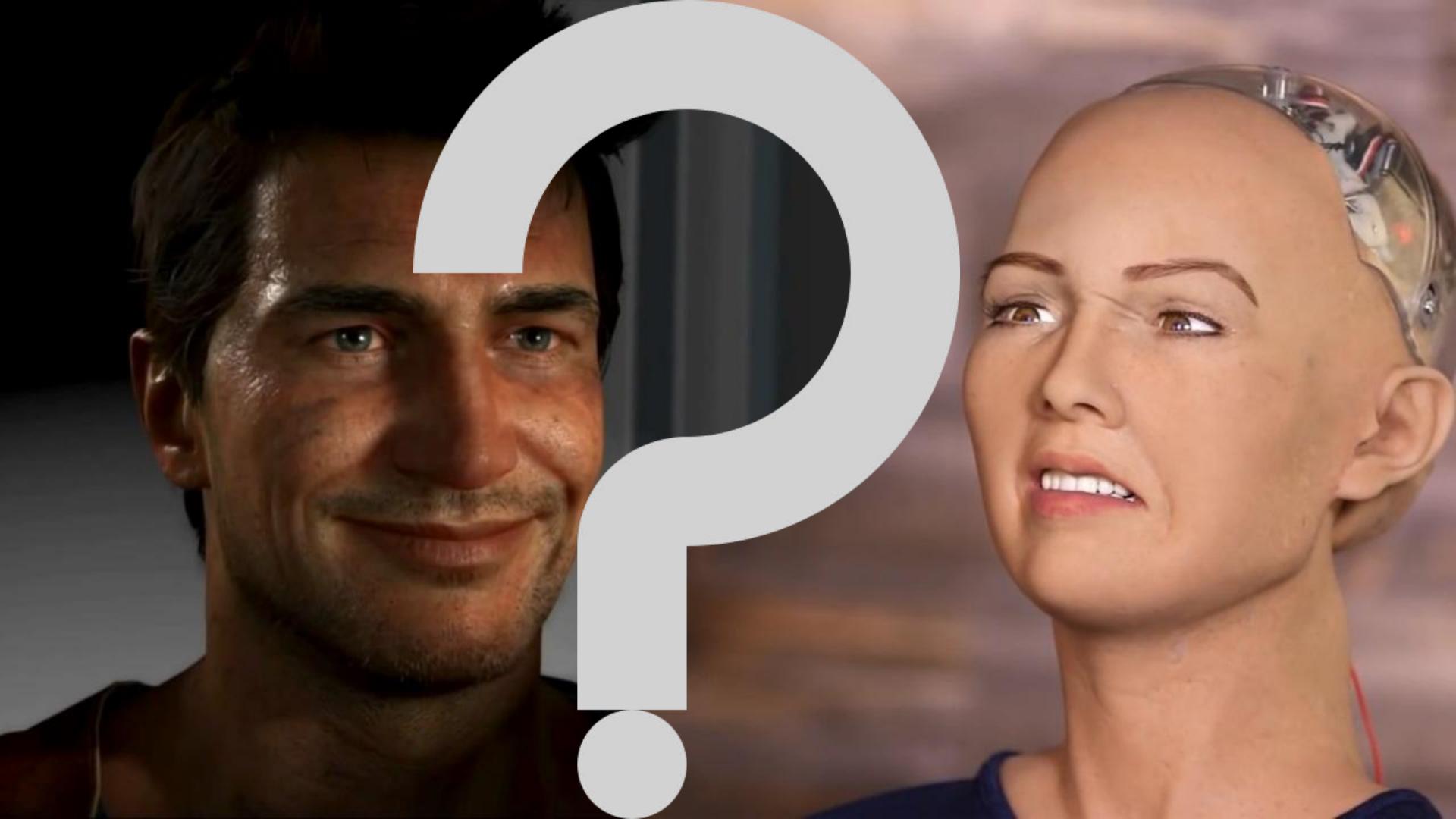
The diagram illustrates a complex system architecture. At the center is a node labeled "IA". From this central node, several lines radiate outwards to various other nodes. Most of these peripheral nodes are labeled "Renderização Física". Some of these "Renderização Física" nodes have additional labels: "Input" and "Física". There are also a few other types of nodes, such as "Táctil" and "Luz", which are also associated with "Renderização Física" nodes. The connections between all nodes are represented by lines, indicating data flow or dependencies within the system.



**16.7**

**milissegundos**

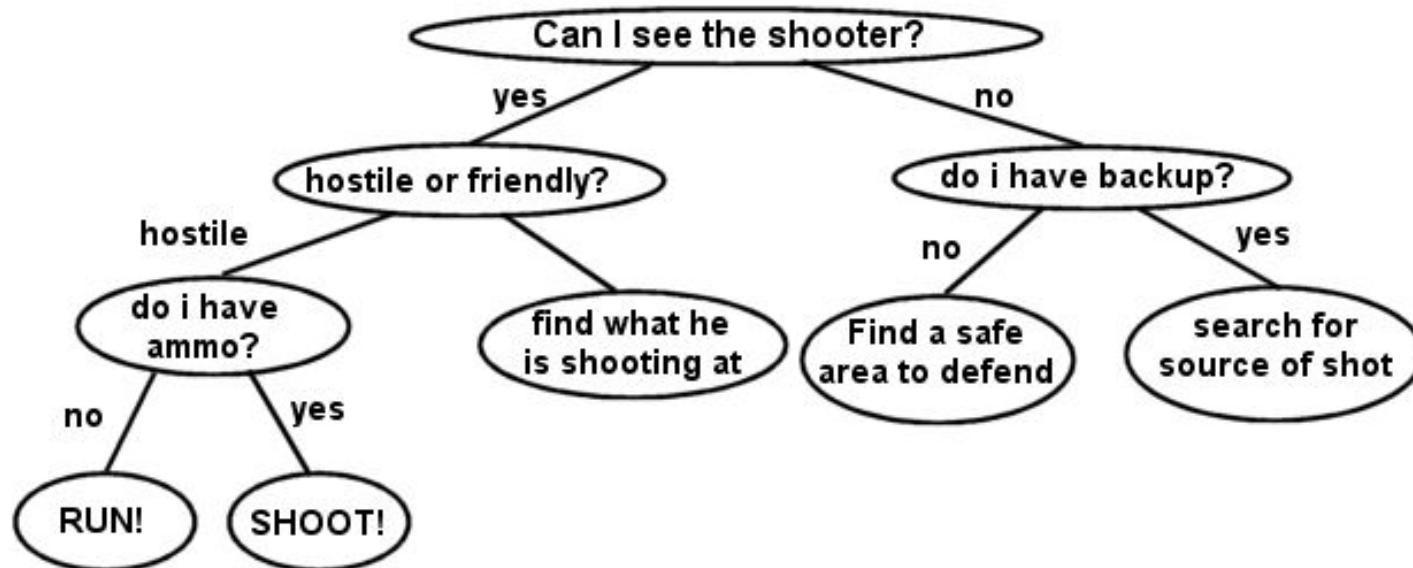




# Exemplos de Técnicas utilizadas



## Árvores de decisão



# ALERT



# 危險

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Máquina de  
Estados  
Finitos



99.99

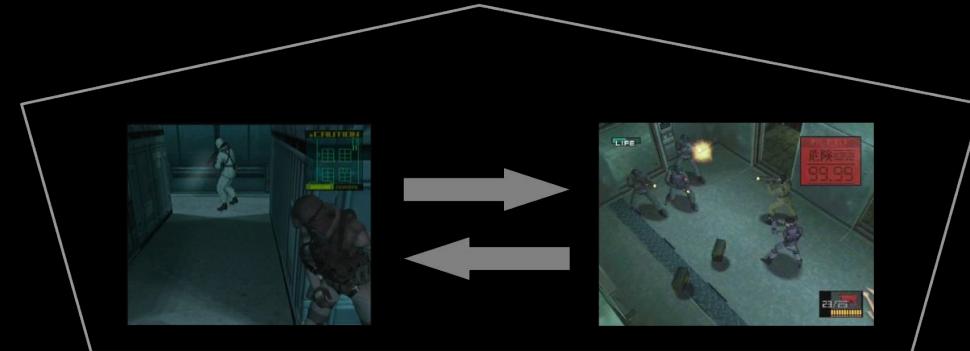
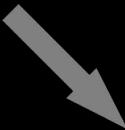


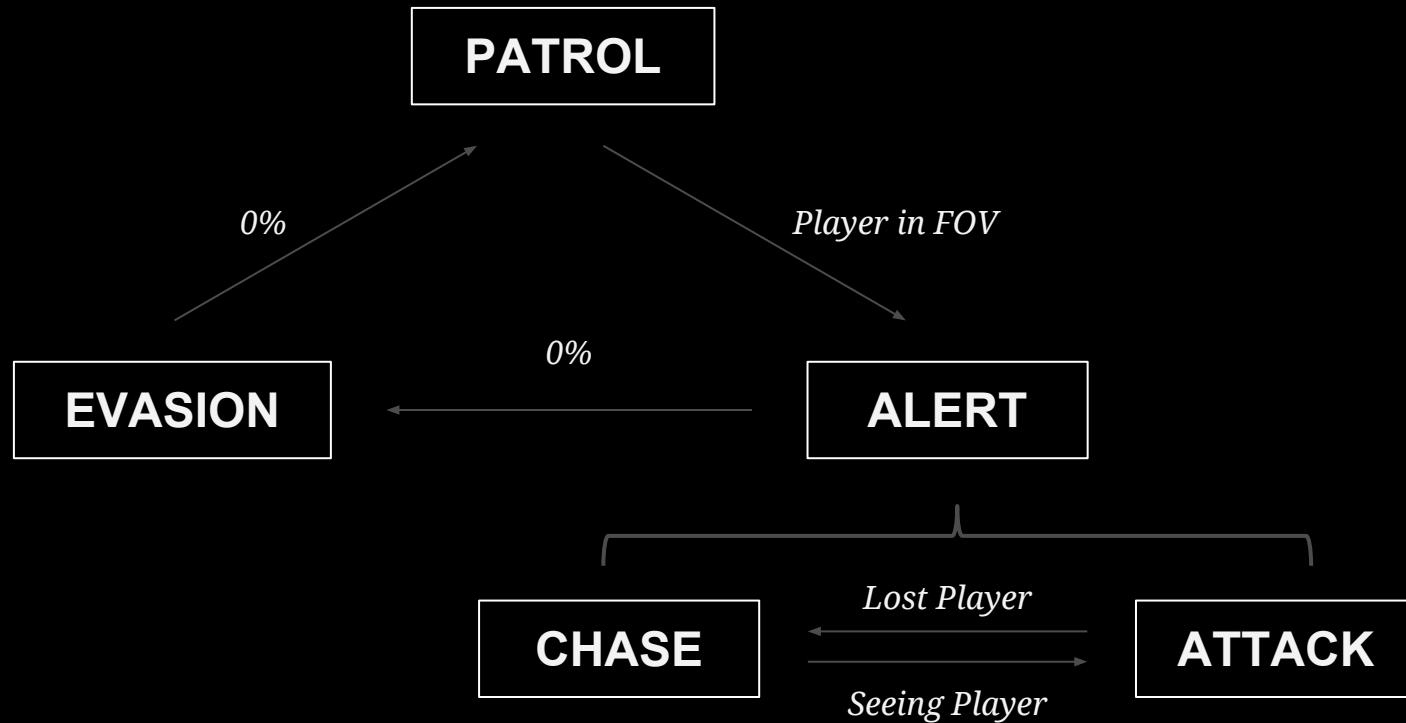
TACTICAL ESPIONAGE ACTION

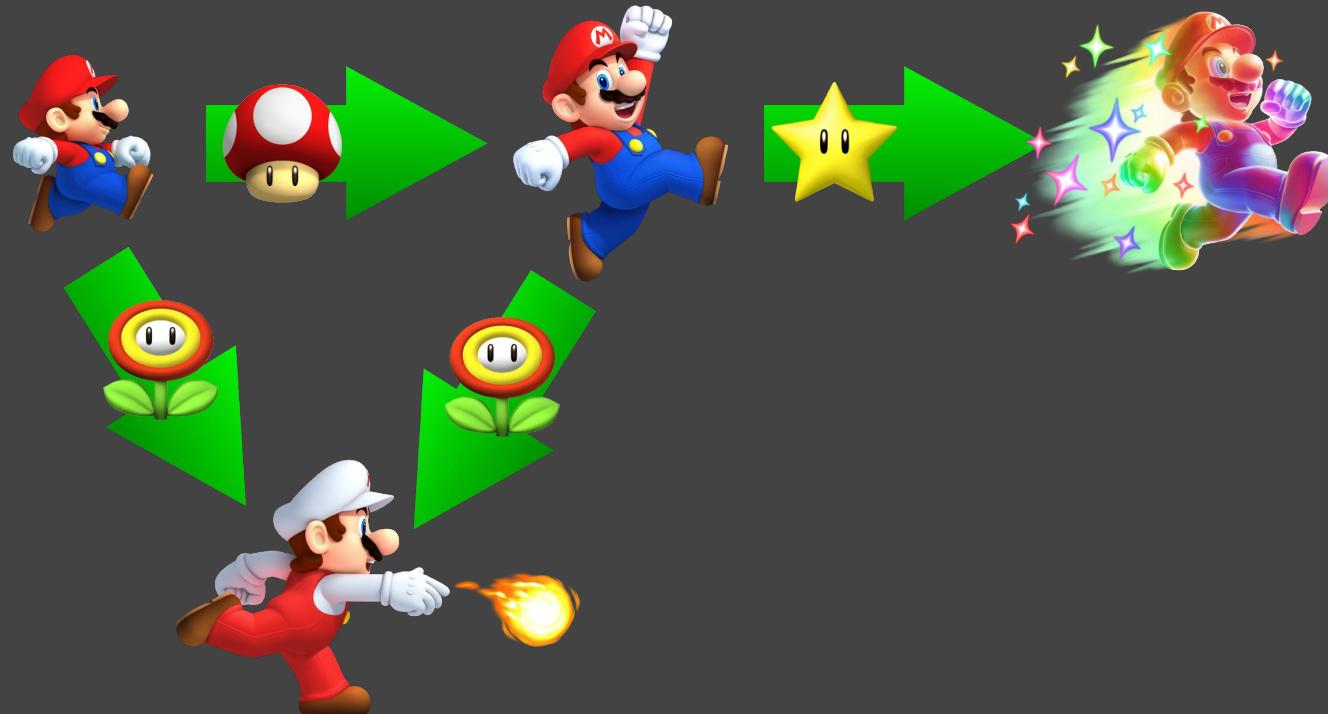
**METAL GEAR**<sup>TM</sup>

S O L I D

The image features a large, high-contrast silhouette of a soldier in a crouching position, holding a rifle, set against a light gray background. The silhouette is composed of dark red and black shapes. To the right of the silhouette, the title "METAL GEAR" is displayed in a bold, red, sans-serif font. Above "METAL GEAR", the words "TACTICAL ESPIONAGE ACTION" are written in a smaller, red, all-caps font. Below "METAL GEAR", the word "SOLID" is written in a smaller, red, all-caps font. A small "TM" symbol is located at the top right of the "G".







# No mundo real

## Combinação de diversas técnicas:

Árvores de decisão (Decision Trees)

Máquinas de Estado Finito (FSM)

Funções de Utilidade

Árvores de Comportamento (Behavior Trees)

Lógica Fuzzy

Sistemas de Markov

...

Combinação de diversas  
técnicas:

Árvores de decisão (Decision Trees)

Macacos de Estado (POMDPs)

Funções de Utilidade

Árvores de Comportamento (Behavior Trees)

Ótimas Funções

Sistemas de Markov

**E ISSO É SÓ PARA  
REALIZAR  
TOMADA DE DECISÃO!**

...

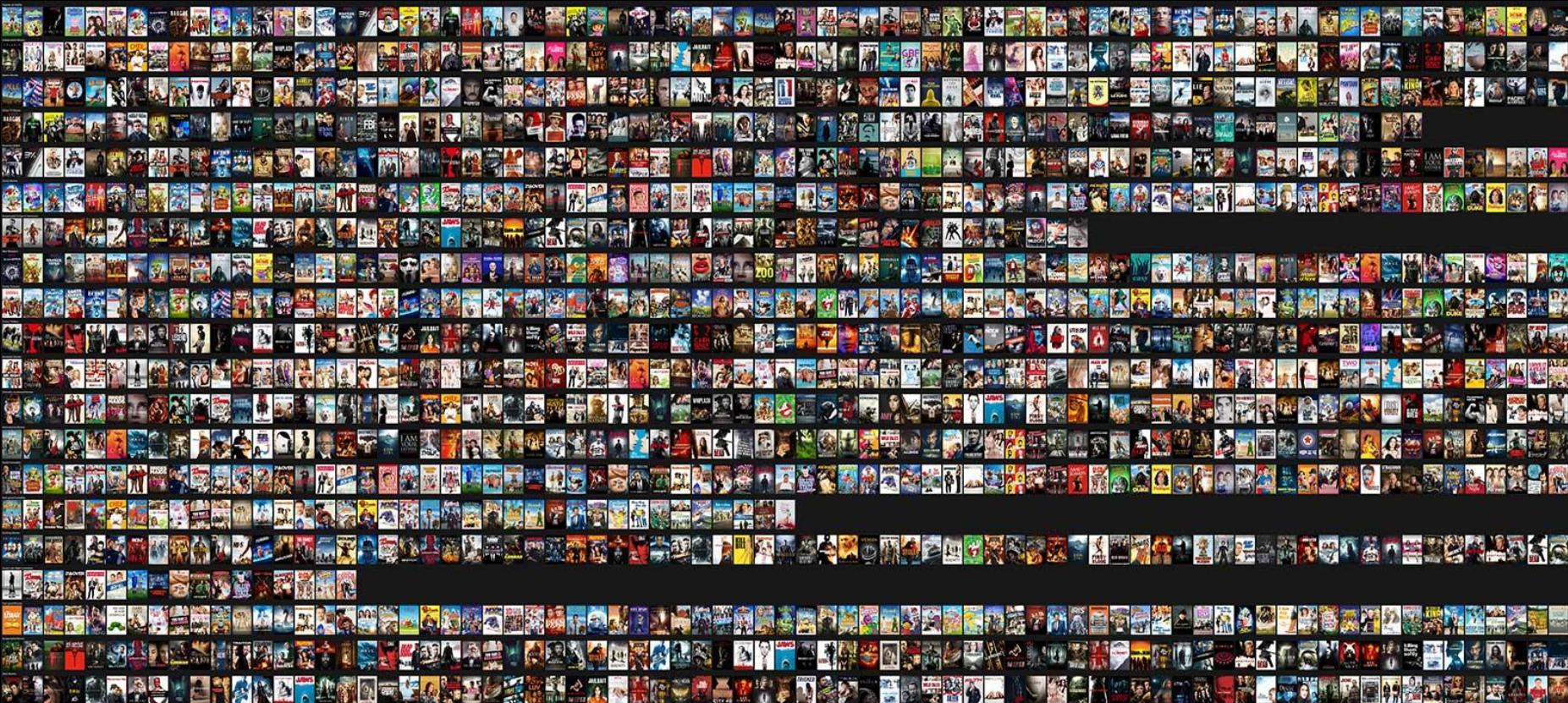
**No mundo  
real**

**Movimentação  
Pathfinding  
Tática e Estratégia  
Aprendizado  
Arquiteturas de IA**

...

**Como fazer  
a IA do  
meu jogo**





**Qual filme devo assistir hoje?**

**Quem são os personagens?**

**Quantos recursos estão disponíveis?**

**Quais os principais objetivos?**

**Quais são os comportamentos esperados?**

**Quais são as restrições?**

*Para as suas próprias perguntas,  
encontre as respostas...*



Não  
complique.

# Muito obrigado!

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