# Introduction to Artificial Intelligence 6: Adversarial Games: additional notes

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## History of AI and adversarial games



#### Checkers

function with reinforcement learning (!)



### Chess:

1982: a program achieves the "Master" level. 1996: Garry Kasparov defeated Deep Blue 4-2 1997: In a rematch, Kasparov lost agains Deep Blue 3.5-2.5. 2017: AlphaZero defeats Stockfish



amazon.com

### Go:

More difficult than chess 2015: still programs were at the amateur level 2015: European champion defeated by AlphaGo 2016: 4th-worldranking champion defeated by AlphaGo

- 1950s: Developed on an IBM 704 (1kHz clock) a program able to learn the evaluation
- 1992: The CHINOOK program came close to the performance of the best player. 2007: Checkers was "solved": the game is always a draw in case of perfect playing.
- 1990: DEEP THOUGHT achieves the "International Master" level.

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# History of AI and adversarial games



#### Backgammon

1663: G. Cardano analyzed mathematically the game 1980: BKG program defeated the world champion 1995: TD-Gammon with an NN learning the utility function plays at world-champion level.





Othello (Reversi)

Since 1997: programs play far better than humans.

amazon.com



wikipedia

#### Poker

2017: world champions defeated (Texas hold'em) by the program Libratus 2019: The Pluribus program won at 6-players games (Texas hold'em)

Bridge Like human champions in playing the hand but not great in the bidding phase.

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# The (now) legendary DeepBlue-Kasparov Match

### **IBM** DeepBlue



wikipedia

### 11.38 Gflops 30 PowerPC 200MHz CPUs 480 custom dedicated chips

#### The contenders:

### Garry Kasparov



wikipedia

### Born in 1963 ELO points at the time: ~2800 FIDE world champion until 1993





DeepBlue Algorithm:

**Alpha-Beta search** with 100 millions states evaluated per second. For some branches, the tree depth could reach 40.

into 8,000 parts. Many of these parts were designed for special positions.

games of grandmasters.

- The evaluation function had many parameters and their values were determined by analyzing O(1000) games by professional players. The evaluation function was split
- The opening database contained >4,000 positions and 700,000 grandmaster games. The endgame database contained many six-piece endgames and all five and fewer piece endgames. An additional database (the "extended book") contained complete







## History of the Match

1989: Deep Thought looses to Garry Kasparov

- 1996: Deep Blue looses again, but became the fist machine beating a (reigning) world champion.
- 1997: An upgraded Deep Blue wins agains Kasparov

Game #	White	Black	Result	Method of conclusion	Game #	White	Black	Result	Method of conclusion
1	Deep Blue	Kasparov	1–0	Resignation	1	Kasparov	Deep Blue	1 <b>—0</b>	Resignation
2	Kasparov	Deep Blue	1–0	Resignation	2	Deep Blue	Kasparov	1 <b>–0</b>	Resignation
3	Deep Blue	Kasparov	1/2—1/2	Draw by mutual agreement	3	Kasparov	Deep Blue	1⁄2—1⁄2	Draw by mutual agreement
4	Kasparov	Deep Blue	1/2—1/2	Draw by mutual agreement	4	Deep Blue	Kasparov	1⁄2—1⁄2	Draw by mutual agreement
5	Deep Blue	Kasparov	0—1	Resignation	5	Kasparov	Deep Blue	1⁄2—1⁄2	Draw by mutual agreement
6	Kasparov	Deep Blue	1–0	Resignation	6	Deep Blue	Kasparov	1 <b>—0</b>	Resignation
Result: Kasparov–Deep Blue: 4–2					Result: Deep Blue-Kasparov: 3½-2½				

#### The 1996 match

Kasparov could not believe that a machine could have made a certain move and accused the IBM team of cheating consulting a human player. Could have it been? K. thought DB was <u>tactically</u> very good but could not believe its <u>strategic</u> proficiency.

#### The 1997 rematch

from Wikipedia

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6

## How the second game went?



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Starting position

Opening line: Ruy-Lopez (Spanish game) Kasparov prefers the Sicilian but he tries to follow closed positions since he thinks the computer is better tactically.







Situation at move 36: what would YOU do?

7

### How it went?

### 37: Be4 (!)

At this point Kasparov started to believe that a machine couldn't have done such a move.

The machine consulted a human? <u>Ironically today we</u> accuse humans to consult machines...

Kasparov resigned at move 45.

After the 5th match the situation was even: 2.5-2.5. The 6th match was finally won by Deep Blue.



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