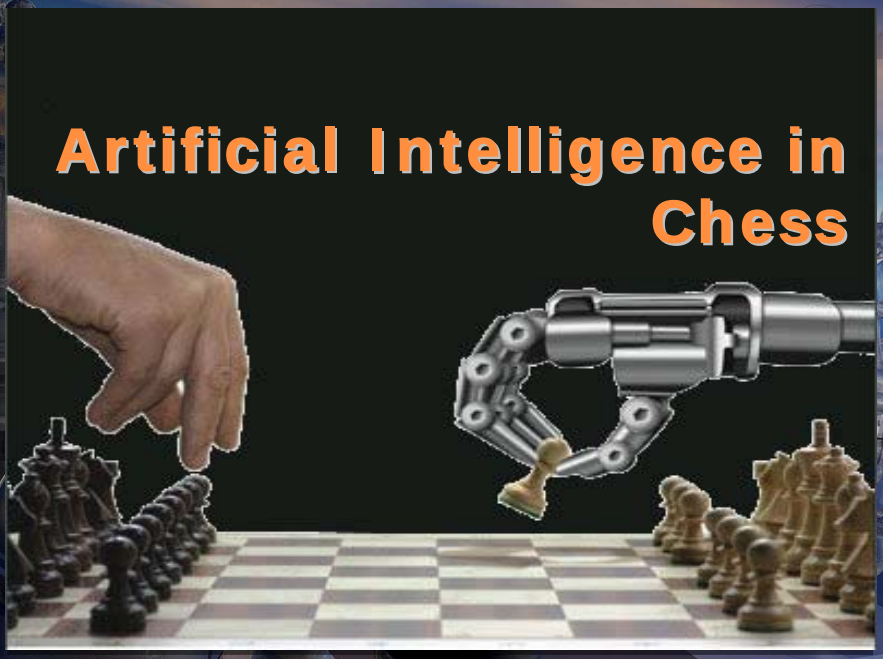
Artificial Intelligence in Chess



Introduction

IA in Chess is quite complex

- Even the fastest computer cannot solve the chess game (cannot analyze every possible situation)
- There are many ways of reducing the need of computational power

The best machine is now slightly better than the best human player

History

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The basis
Search techniques
Position Evaluation
Use of databases
Discoveries thanks to Computer Chess
Future of IA in chess (and more)

1769 – The turk

Automaton made By Wolfgang van Kempelen

Played famous people including Napoleon

Obviously cheated (no-legged man inside)

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1912 – El Ajedrecista

Automaton build by Leonardo Torres y Quevedo

Played an endgame with King and Rook vs King

Could always win

Could detect illegal moves

History

1950s – Very beginning of computer chess

1960s – Good enough to beat novice players sometimes

1977 – First tournament win for a program (*Chess 4.5*, Minnesota Open)

History

Computers vs World Champions

1985 – Kasparov vs 15 chess computers. Won every single game

1992 – Kasparov vs *Fritz 2* in a *speed game*. Won 6.5 – 4.5. First time a computer defeats a world champions

1996 – Kasparov vs *Deep Blue (IBM)* won 4-2. First time a computer defeats a world champion under tournament conditions

1997 – Rematch : Kasparov vs *Deep Blue II*, lost 2.5 – 3.5. A great milestone in computer chess

(…)

2006 – Kramnik vs Deep Fritz, lost 4-2

Glossary

Pawn

Knight

Bishop

Rook

Queen

King

A *ply*: one move for one player

A *move:* two plies

The basis

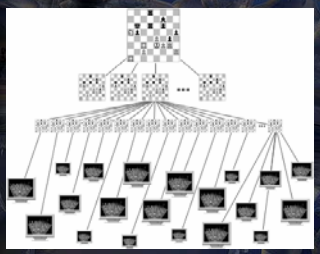
It's impractical to consider every possiblity so choices must be made by the use of *search techniques*

A chess computer...

•Usually builds the whole *tree* for the few next plies

•Decides which nodes are worth a research

•Uses MANY features to decide how deep the search of a node should be

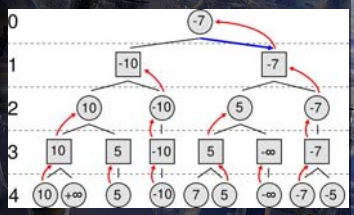


Search techniques

The Minimax algorithm

A value is affected to each « final » position

The current player will choose the path that gives him the best moves and gives the opponent the worst ones



Problem : Too many positions in chess
- Average of 30 legal moves
- Typical games take 80 plies

*Number of positions to evaluate: 30^80 = 1*10^118*

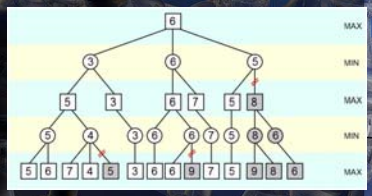
Note: It is believed that there are 10^75 atoms in the Universe…

Search techniques

Alpha-beta pruning

Improvement of the Minimax algorithm that reduces the number of nodes that must be evaluated

Stops evaluating a move (triggers a cutoff) when at least one better possibility has been found elsewhere



From left to right

Alpha-beta pruning usually allows to double the efficiency of the minimax algorithm (when using ***killer heuristic***). It makes the search **non-uniform**, which is obviously very important

Search techniques

Credits

Credits = certain amount of extra plies. Can be negative.

The algorithm evaluates a 10 plies depth tree. The credit generation will allow some moves to be evaluated deeper and will prevent some other moves from reaching the 10th ply

Search techniques

In which cases a move is given credit:

- *Forced moves*: there are less legal moves so the subtree is smaller than usual (i.e. faster to analyze)
- *Principal variation*: in the tree, one move seems to be very good for both players
- Singularity, binarity,… (a move is much better than the others)
- http://turbulence.org/spotlight/thinking/

Position evaluation

We could see that the whole algorithm depends on evaluating how good a position is (what is its score)…

But it's actually very complex to tell how good a position is. Many factors, with different weight, that varies with time, must be considered

The estimated value of a position is:

```
V = factor1 * coeff1 + f2 * c2 + f3 * c3 +…
```

The coefficients are parameters that can change depending on the time of the game (beginning, middle or end), the opponent… and we don't know their optimal values

Position evaluation

List of factors

Material value
Pawn 1, Knight 3, Bishop 3, Rook 5, Queen 9, King infinite. This is a simplified approach… click here

King safety (stay in the corner at the beginning, have a pawn shield,…)

Mobility (knights rather in the center)

Pawn structure (Isolated pawns, blocked pawns,…)

Was the move ever played in a top-level game?

Use of databases

Databases of pre-processed position evaluation and of hundreds of famous games from top players are used in some cases: mainly for openings and endgames.

Openings

Database of early possible opening positions

Deep-blue: Database of 4.000 positions that have been processed. There is a statical evaluation value for those 4.000 positions. This way, Deep Blue can choose positions that will provoke a type of game that it often wins

Use of databases

Endgames

The less material remains on the board, the less legal moves there are, the smaller the tree is… It becomes possible to compute every single position

This has been done for every positions with 5 pieces or less on the board. The results are stored in the endgame database (7Gb). Additionnaly, some 6 pieces positions are also stored. Saving all 6 pieces positions would take 1.2Tb.

Discoveries

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A few discoveries have been made by chess computers, especially for endgames (when the full databases are available, so they can be played perfectly)

Fifty move rule: « The fifty move rule states that a player can claim a draw if no capture has been made and no pawn has been moved in the last fifty consecutive moves ».

Positions* believed to be won turned out be drawable if played correctly. The fifty moves rule has even been (temporarily) modified because of this.

But it actually does not make any difference for the human player, who doesn't manage to play the position perfectly.

*
- Queen vs 2 bishops
- Queen vs 2 knights
- 2 bishops vs a knight
- 2 knights vs a pawn
- Rook and bishop vs rook

Future

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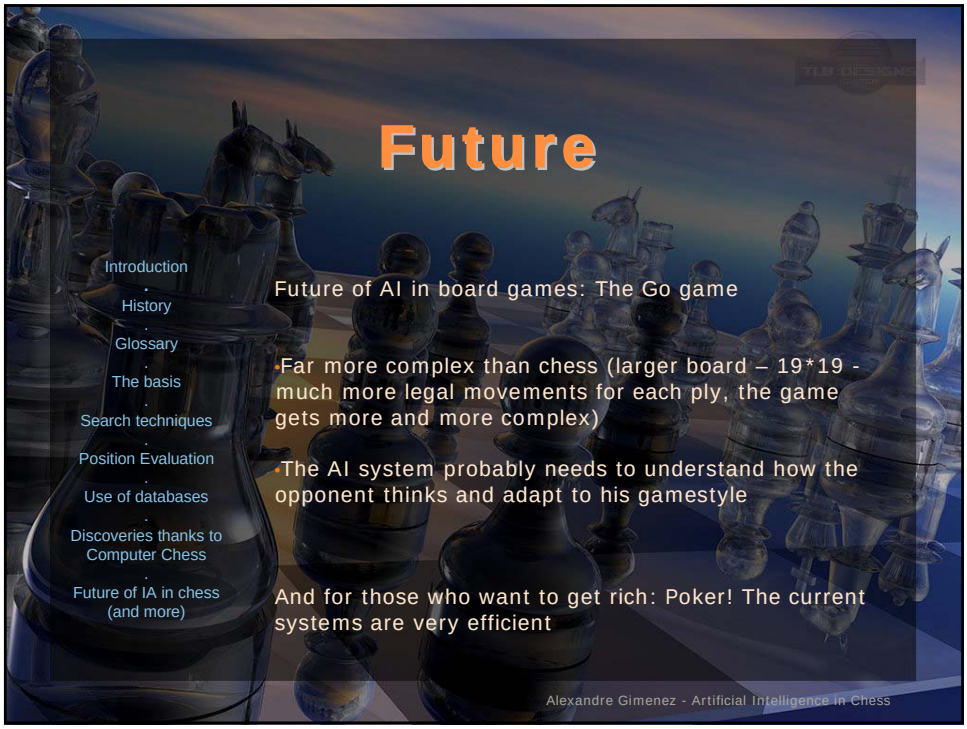
Future of Chess

- System that would always beat a human (should happen quite soon)

Interesting project: Chess Brain
Uses a grid (thousands of computers connected through Internet) in order to use a much higher computational potential

- Solving chess? (very unlikely)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Future of AI in board games: The Go game
•Far more complex than chess (larger board – 19*19 - much more legal movements for each ply, the game gets more and more complex)
•The AI system probably needs to understand how the opponent thinks and adapt to his gamestyle
And for those who want to get rich: Poker! The current systems are very efficient
Alexandre Gimenez - Artificial Intelligence in Chess