

Chess and Computing

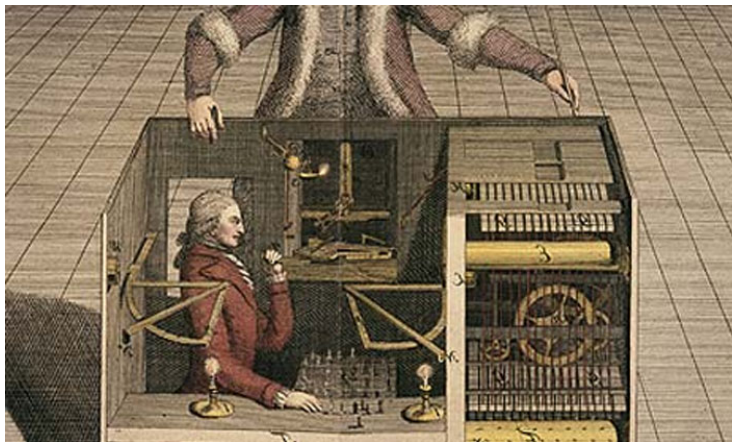
Sylvain Julmy

November 16, 2017

History

- 1769 : The Turk automaton
- 1912 : First machine who “play chess”
- 1950 : First paper by Claude Schannon
- 1951 : First complete program by Alan Turing (without a computer)
- 1997 : Garry Kasparov loose against Deep Blue
- 2000+ : Computer are just better than Human

The Turk automaton



The Turk automaton



Alan Turing vs Alick Glennie

First victory of a computer program



Deep Blue



Deep Blue



Deep Blue - Specification

- Computer class: mainframe
- Architecture: parallel, based on SP2 technology
- 32 Power2 SC cpu's
 - 135 Mhz
 - 32 bit registers
 - RISC
 - 15'000'000 transistors
- 512 Chess processors
- 10^{12} operations per second
- 500 computation threads, $1.2m^2$ foot print
- 259th of the TOP 500 in June 1997

Chess engine

Components :

- Board representation
- Search techniques
- Leaf evaluation
- Endgame tablebases

Board representation

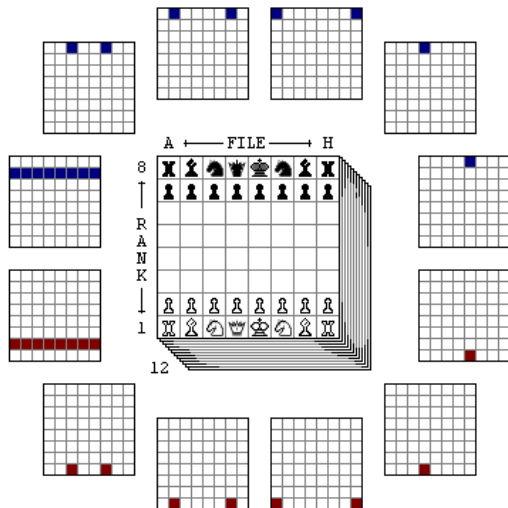
- Object Oriented concept
- A chess board has 64 squares...
 - Use a bitboard representation !
 - Other usage too : game of life, connect four, ...

Board representation

Some "magic" happens

- Reduce the number of cpu instructions.
- Massive compression and encoding \implies hard to write and debug !
- Improve pipelining.
- Need a 64 bits architecture.

Board representation



Board representation - Programming Pearl

```
int t(int a, int b, int c) {
    int d=0, e=a&~b&~c, f=1;
    if (a)
        for (f=0; d=(e-=d)&-e;
             f+=t(a-d,(b+d)*2,(c+d)/2));
    return f;
}

int main(int q) {
    scanf("%d",&q);
    printf("%d\n",t(~(~0<<q),0,0));
}
```

Board representation - Programming Pearl

Solve the 8-queens problem !

```
t(a,b,c){int d=0,e=a&~b&~c,f=1;if(a)for(f=0;d=e&-e;f+=t(a-d,(b+d)*2,(c+d)/2))e-=d;return f;}main(q){scanf("%d",&q);printf("%d\n",t(~0<<q,0,0));}
```

Search techniques ¹

- Type *a* : Brute force
- Type *b* : Quiescence search (horizon effect)

¹Claude Shannon, 1950

Search techniques

- Minimax
- Alpha-beta pruning
- Killer heuristic
- Iterative deepening depth-first search
- Null-move heuristic
- Late Move Reductions

Search techniques

Globally, some kind of brute-force with heuristic because the chess game is in *EXPTIME*-complete.

Evaluation

$$c_1 * material + c_2 * mobility + c_3 * kingSafety + \dots$$

A lot of factor : mobility, material, activity, king safety, pieces safety, pawn structure (doubled, backward, isolated), weak squares, center control, connectivity (information theory), tempo, game phases (opening, middle game, endgame),...

For example, in Stockfish the evaluation function is more than 800 lines of codes.

Search techniques and evaluation

Alternative, use machine learning... like AlphaGo !

Search techniques and evaluation

In 2015, a deep learning machine teaches itself chess in 72 hours and plays at an International Master Level ²

²“Using Deep Reinforcement Learning to Play Chess”, Matthew Lai

“Play chess with God” Ken Thompson

Endgames tablebases

Start from a checkmate position and perform retrograde analysis

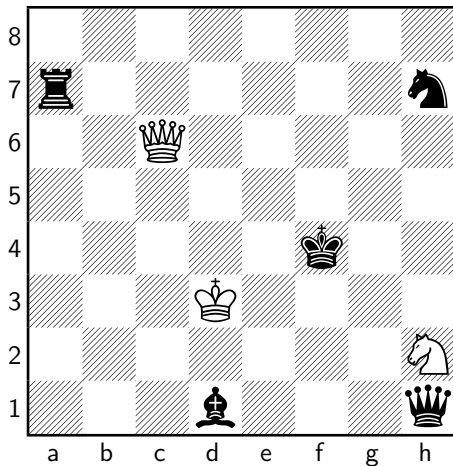
In 2005, all the endgames up to 6 pieces had been solved. (≈ 1153 GB)

In 2012, all the endgames up to 7 pieces had been solved (≈ 100 TB, with heavy compression and tricks). 8-man tablebases is $\approx 10PB$ (estimation).

In 2016, Mark Watkins from Sidney University solved entirely a chess variants known as “Losing Chess”... $1.e3$ wins for white in any variation !

Endgames tablebases

Even some fun appears with tablebases !



White mate in 546 moves

The God's Algorithm

“A grandmaster wouldn't be better at these endgames than someone who had learned chess yesterday. It's a sort of chess that has nothing to do with chess, a chess that we could never have imagined without computers. The Stiller moves are awesome, almost scary, because you know they are the truth, God's Algorithm - it's like being revealed the Meaning of Life, but you don't understand a word.”

Ratings chess engines

<http://www.computerchess.org.uk/ccrl/4040/>

Ratings chess engines - World Computer Chess Championship

- Open to all kinds of computer including microprocessors, supercomputers, clusters and dedicated chess hardware.
- Winner receive the trophée Shannon.
- Since 1974 !

Ratings chess engines - World Computer Chess Championship

Program	Nat.	Authors	Operators	Cores	Architecture	GHz
GridGinkgo	Ger.	Frank Schneider, Kai Himstedt, Robert Hyatt	Timo Haupt, Kai Himstedt	224	AMD + Intel mix	3.4
Hiarcs	GB	Mark Uniacke	Harvey Williamson, Hans v.d. Zijden	28	Intel Xeon E5-2697	2.7
Jonny	Ger.	Johannes Zwanzger	Johannes Zwanzger	2400	AMD x86-64	2.8
Komodo	USA	Don Dailey, Larry Kaufman, Mark Lefler	Mark Lefler, Erdogan Günes	48	Intel I7	2.8
Raptor	USA	Steve Webber	Wolfgang Zugrav	12	Intel Xeon X5680	4.1
Shredder	Ger.	Stefan Meyer-Kahlen	Stefan Meyer-Kahlen	32	Intel I5-2697	2.6

Ratings chess engines - TCEC

Rules and technical specification change each year.

The un-official World Championship

<https://go.twitch.tv/tcecpoc>

Last year, the game of the year was between two chess engines.

Testing chess engines

- Nolot : 11 very difficult positions from real games, particularly hard to solve for chess engines. In 1994, the Diablo 68000 took 7.5 months to solve one of the problem. In 2016, Stockfish took 7 seconds...
- BT2450 and BT2630 for tactical capability
- Brilliancy
- ...

At first Nolot attempt, it took 14 months and 1 days to obtain... a power failure and a lost of 80'000'000'000 analysis nodes.

Is it possible to solve chess ?

Yes !

→

Zermelo's theorem

Even on a infinite board ! Except for some strange variants

$$10^{120}$$

Different possible chess of games

Shannon number

Between $4 * 10^{79}$ and $4 * 10^{81}$

The number of atom in the known universe

Kasparov versus the World

- Kasparov vs. 50'000 people from 75 countries using the internet.
- 62 moves played over four months
- 24 hours per moves
- World resign after Kasparov demonstrate a mate in 28 moves in the final position by using tablebases endgames.

Kasparov versus the World

“It is the greatest game in the history of chess. The sheer number of ideas, the complexity, and the contribution it has made to chess make it the most important game ever played.”

Garry Kasparov

You want more ?

<http://chessprogramming.wikispaces.com/>

Thank's for your attention !



"BAD NEWS — THE DRINKS MACHINE WON"