Nov. 1976

T.A. MARSLAND,
Computing Science Dept.,
University of Alberta
Edmonton T6G 2H1

also

c/o Computing and Control Dept.,
Imperial College
London

"The World Computer-chess Championships" Hayes & Levy.

In addition to listing the chess moves made in the first world championship the book also contains an algorithm for King and Rook against King endgames. Results of a questionnaire submitted to audiences and chess players are presented, nothing very exciting

Use of 10 x 12 board is expounded – should have referenced TECH here. That board is essentially the one used in international postal chess play, each square is represented by two digits, each digit corresponding to a row or column. Each type of piece is represented by a unique digit. Thus all pawns are represented by a '1'.

Omissions

No mention of 8 x 8 board. This is especially attractive for machines with good octal arithmetic capability. No mention of merits of distinguishing between individual pawns. By that means a ~~sab~~ different value can be associated with each pawn, depending on its relative position and worth. Commonly values for pawns are re-computed at instant of capture (or usage) leading to even more special code. ~~Fo~~ Of course the 10 x 12 board simplifies the edge detection problem, but use of "direction indices", as in the T. BELLE case, are just as good.

Notes on existing Programs

FREEDOM and PAPA both use mobility as their primary term in their evaluation function. As with WITA, both use the ratio of computer's moves / opponent's moves. PAPA and WITA also multiply by the ratio of the squares controlled and PAPA goes one step further and takes the logarithm of this product to form the "entropy" of the position. The true merit of this entropy over the product ratio was not made clear, but it does ensure that in extreme situations the evaluation remains more closely bounded.

KAISSA, the Russian program, is interesting because for the first time substantial details of the factors considered by the program are included. Different evaluation functions are used to handle the middle game and endgame, and a special checkmate detector is included. The values of the pieces are

P = 2,	N = B = 7,	R = 10,	Q = 20,	K = ?	KAISSA
6	18 20	30	57	60	WITA

Good Features which are considered by the program are

ⓐ A phalanx, two pawns side by side on ranks 4–7 for White. Three pawns side by side count as two phalanxes.

ⓑ Centre pawns

ⓒ Pawn attack on centre

ⓓ Passed pawns

ⓔ Scope: The influence that each piece exerts on all squares, occupied or unoccupied, by own or enemy pieces.

CHAOS does a complete 2-ply analysis and this is ~~ep~~ used to pre-order the selective search. Ordering is done at each level and a killer heuristic is employed for dynamic re-ordering. If a number of non-productive moves (no improvement in backed up value) occur in sequence, the variation is terminated - provided the minimum number of moves have been examined. Typical the program ~~hat~~ is required to look at between 3 and 6 moves at each node, but no more than 10. Checks, captures, promotions and other important moves automatically cause an increased depth of search. A relative scoring evaluation is employed.

$$\text{EVAL} = \frac{1000 * \text{value (side)}}{\text{value (side)} + \text{value (opponent)}}$$

This has the advantage that the final score is always within the range [0, 1000]. Ninteen factors are included in the function:-

(a) Σ value all pieces under "attack" (but not necessarily lost)

(b) Capturing potential, giving credit for many pieces enprise.

(c) Mobility = # legal moves

(d) Centre control, occupancy and attack of centre squares - reducing.

(e) Pins and discovered checks

(f) Material baland — an overwhelming consideration.

(g) Penalty for early queen devellopment.

(h) Double threats and captures = value of second most valuable piece able to be captured by moving piece. Comparable to WITA's EPSCORE.

Now that the OSTRICH program is being replaced by L'EXCENTRIQUE I shall assume that all the features of the old will be incorporated into the new. The two most important segments are: plausibility analysis & evaluation. Other segments are: user communication, tree search, table update.

Three major data structures exist

ⓐ Square from-to plus capture info.

ⓑ List of squares each piece controls

ⓒ Change list, necessary info. to retract a move.

Other lists exist to keep track of pinned pieces, enprise pieces, refutations, principal variation, last 'N' reversible moves.

Generous 'fan out' parameters are set for the fixed depth, depth-first search. Captures and checks are expanded from the minimum depth of search to a predetermined maximum. The fan-out and minimum search depth are adjusted every three moves on a basis of the average time taken per move.

A flow chart of the plausibility analysis is provided and accounts for such factors as: Captures (of overwhelming importance, terminating further analysis), castling, pawn threats, rook moves, refutation moves, safe moves (saves material), mixer to encourage moves by large # pieces, rather than large # moves by few pieces.

Static analysis also takes into account additional factors

ⓐ Board control, ability to capture 'hypothetical' piece on given square. Extra credit for control of central squares or those around King.

<u>Experiences gained in constructing and testing a chess program</u> H. J. Berliner.

Summarizes some of the work done by H.J.B in period 1968–1972 dealing with a PL/1 program. Stress on need for good tactical analyses, before introducing strategies. Stresses need for quiescence detection and tree termination at quiescent position, rather than fixed depth. Advocates threshold cut off "this process would then be continued until there ~~is~~ no longer appears to be a move that could be better than the best found so far.

<u>Control</u> of a square by a piece involves the ability of that piece to capture a hypothetical enemy man on that square.

To measure the <u>centrality</u> of a square, count # moves possible by a (Queen-Knight super piece - 21)

2	3	4	4	4	4	3	2
3	6	8	8	8	8	6	3
4	8	12	12	12	12	8	4
4	8	12	14	14	12	8	4

Note $21 = 3 \times 7$ = # moves along rank / file diag available on every square.

<u>Effective control</u> of a piece is inversely proportional to its value!

<u>Square control</u> is the algebraic sum of the product of the effective control of the piece and the value of the square

<u>Board control</u> is the Σ square control.

25

Bell's description of some other programs.

Bernstein (1958) did not use α-β pruning (attributed to Samuels ~~Newell, Simon, Shaw~~ or MIT).

(a) Inspects each sq. on board

(a) occupied (b) whose man — Note Table approach provides this.

(c) Attacked (d) Defended

(table approach does not answer)

(e) can it be occupied

Program applies 8 questions. prunes move list to 7.

(1) Am I in check? (2) Capture exist (either side)?

(3) Can I castle? (4) Develop N or B?

(5) Occupy an open file? (6) Enter critical squares of P chains?

(7) Make P move? (8) Make Piece move?

1st 7 moves to make favourable answers to these questions.

Search 4-ply (start at ply 0) perform static evaluation

(1) Gain of material

(2) Defence of King

(3) Mobility of pieces

(4) Control of important squares (centrality).

Bell claims that Bernsteins 7 moves could (almost always) have been obtained from mobility ratio alone. My own work suggests that mobility is important only when there are no other significant factors. In itself it is a good indicator, but subservient to more specific indicators.

"Multi-dimensional structure in the game of chess"   R. H. Atkin

At first glance it looks as though this paper is providing a formal way of specifying concepts like mobility & control. It also introduces the concept of connectivity and tries to show how his notation describes the positional (strategic) factors in chess programs.

Consider :-

Given X = a white chessman, S = square on the board,

then X controls S (i.e. $X \Gamma_W S$) if and only if X attacks S.

By attacks he means

ⓐ X can legally move to S. — Clearly this is wrong for pawns and the castling move.

ⓑ If S contains a white man Y $\therefore$ X defends Y.

ⓒ If X is white K and S is an immediate neighbor.

ⓓ If. Black King is on S, and X "checks" the K. Note if X is pinned it cannot move to S (see ⓐ), but it can still check.

Thus for white we have two complexes (complices?)

$$K_X(S;\Gamma_W) \quad \text{and} \quad K_S(X;\Gamma_W^{-1})$$

In $K_X(S;\Gamma_W)$ — white's view of the board — each man (X) is representing a simplex with vertices selected from the squares of the board. Basically this is fairly close to the move list for the man.

Two pieces X_1 and X_2 are said to be q-connected on the board if they share $(q+1)$ squares on the board. That is, there are $(q+1)$ squares which are attacked by both X_1 and X_2

"A Study of Techniques for game-playing programs" Marsland + Rushton.

After a review of current techniques and a discussion of the complexity problem, the paper ~~new~~ reviews the cost of extending the existing methods for better play. A measure of the effectiveness of different programs is presented and used to show how the coefficients of one polynomial function were improved. Basically the move list was ordered according to the ~~[illegible]~~ function and then the location of the move selected by a master calibre player was noted. For a sample of some ~~384~~ 378 positions from 15 games the % of the moves selected by the master from the 1st, 2nd, 3rd ... position in the list was plotted.

The paper concludes by advocating a return to the goal seeking methods which were abandoned prematurely.

"Programming a Computer to Play Chess" Shannon

This classic paper set the stage for 20 years of computer chess work. The properties of the game are such that

1). The problem is sharply defined both in allowed operations (moves) and in ultimate goal (checkmate)

2). Neither so simple as to be trivial nor too difficult for satisfactory soln.

3). Requires "thinking" for skillful play.

4). The discrete structure of chess fits well into the digital nature of computers.