# Chapter I
# Four Basic Topics
# in AI

# LEARNING

Chapter 1 -  Four Basic Topics:

# 1.4 Learning:
## Machine Learning

- the Game Tree
- the Minimax Technique
- the Alpha-Beta Strategy

For:

- Zero-Sum Games

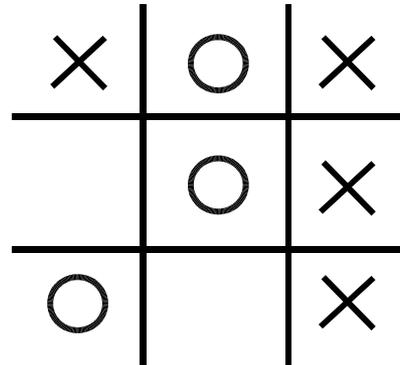- Perfect Information games

… using as an example "Tic-Tac-Toe"

① Example

② Game tree

(possible) first move:

...

...

*But: Redundancy!*

Start node

Best move

Max

6-5=1    5-5=0    6-5=1    5-5=0    4-5=-1

Min

5-4=1    6-4=2

5-6=-1   5-5=0   5-6=-1   6-6=0   4-6=-2

Start node

Best move

4-2=2    3-2=1    4-2=2    2-2=0    4-2=2    3-2=1

4-3=1    3-3=0    5-3=2    3-3=0    4-3=1    4-3=1

4-2=2    4-2=2    5-2=3    3-2=1    4-2=2    4-2=2

4-3=1    4-3=1    3-3=0
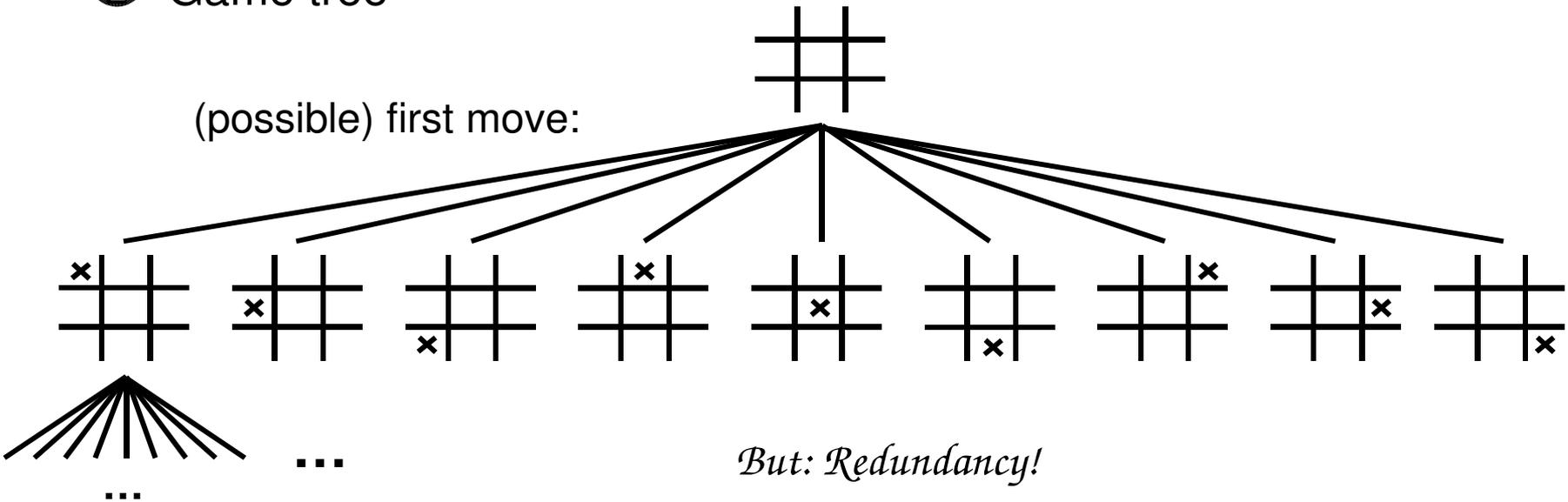
FIG. 5-12 *Minimax applied to tic-tac-toe* (Stage 3).
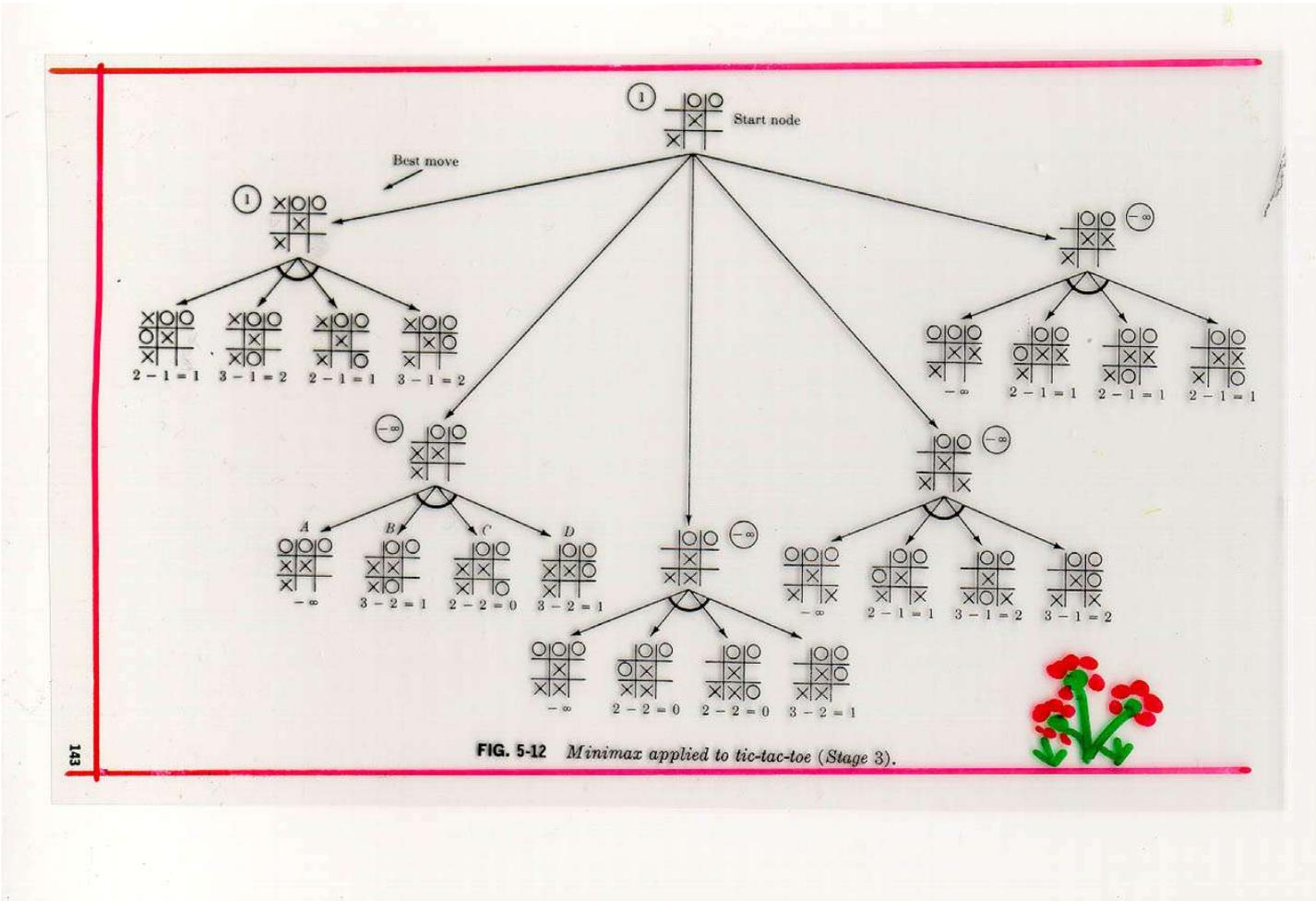
Example: first stage Tic-Tac-Toe



Provisional
backed-up value = -1

Start node

A

-1

B

Provisional
backed-up value = -1

C

6-5=1   5-5=0   6-5=1   5-5=0   4-5=-1                    5-6=-1
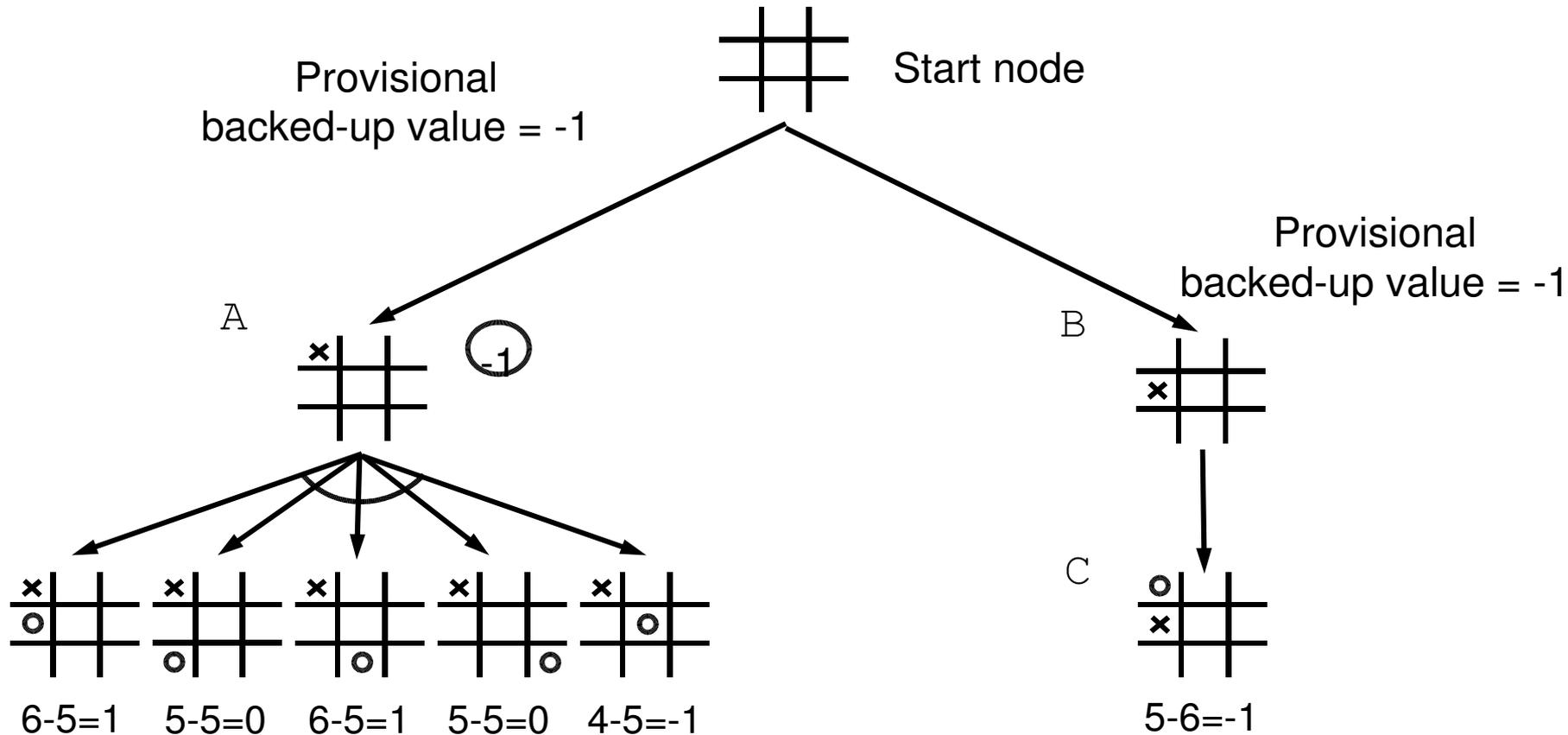
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Note:

- *the backup-value of the Max-Node <u>can never</u> become smaller!*

- *The backup-value of the Min-Node <u>can never</u> become higher!*

Definition:

**ALPHA** value: the minimum of all Max values of the ancestors

**BETA** value: the maximum of all Min values of the ancestors

Rule:

3. The search below a Min-Node can be cut-off, if

   backup-value $\leq$ ALPHA value

6. The search below the Max-knot can be cut off, if

   backup-value $\geq$ BETA-value

# Example illustrating the Alpha-Beta-Strategie

□ AND node
○ OR node

Start node
Backed-up value = +1

0  5  -3  3  3  -3  0  2  -2  3  5  2  5  -5  0  1  5  1  -3  0  -5  5  -3  3  2  3  -3  0  -1  -2  0  1  4  5  1  -1  -1  3  -3  2  -2
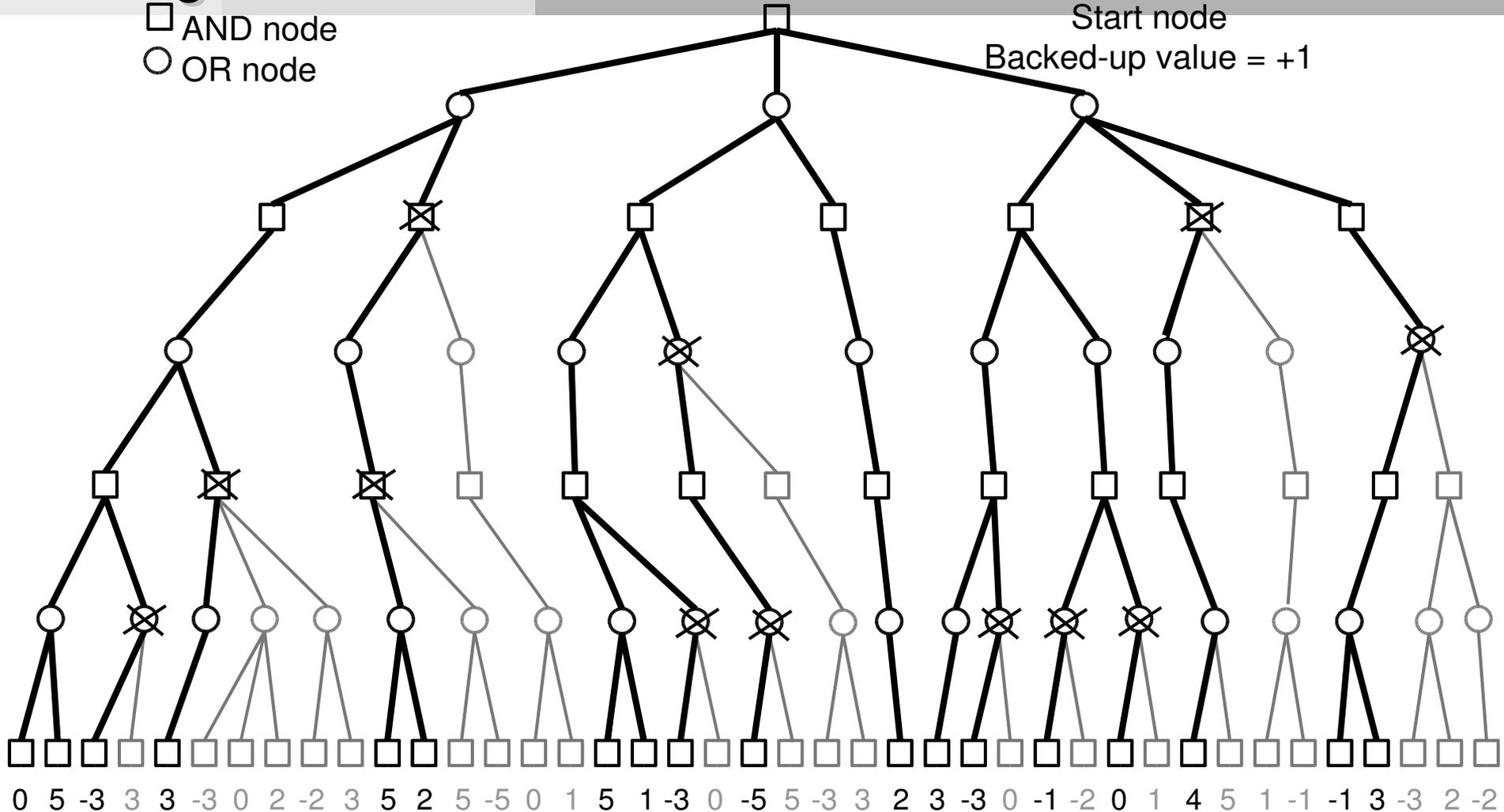
… using the game of checkers
as an example

A.L. SAMUEL

SOME STUDIES IN MACHINE

LEARNING USING THE GAME

OF CHECKERS

(1959)

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# The Game of Checkers: square designations
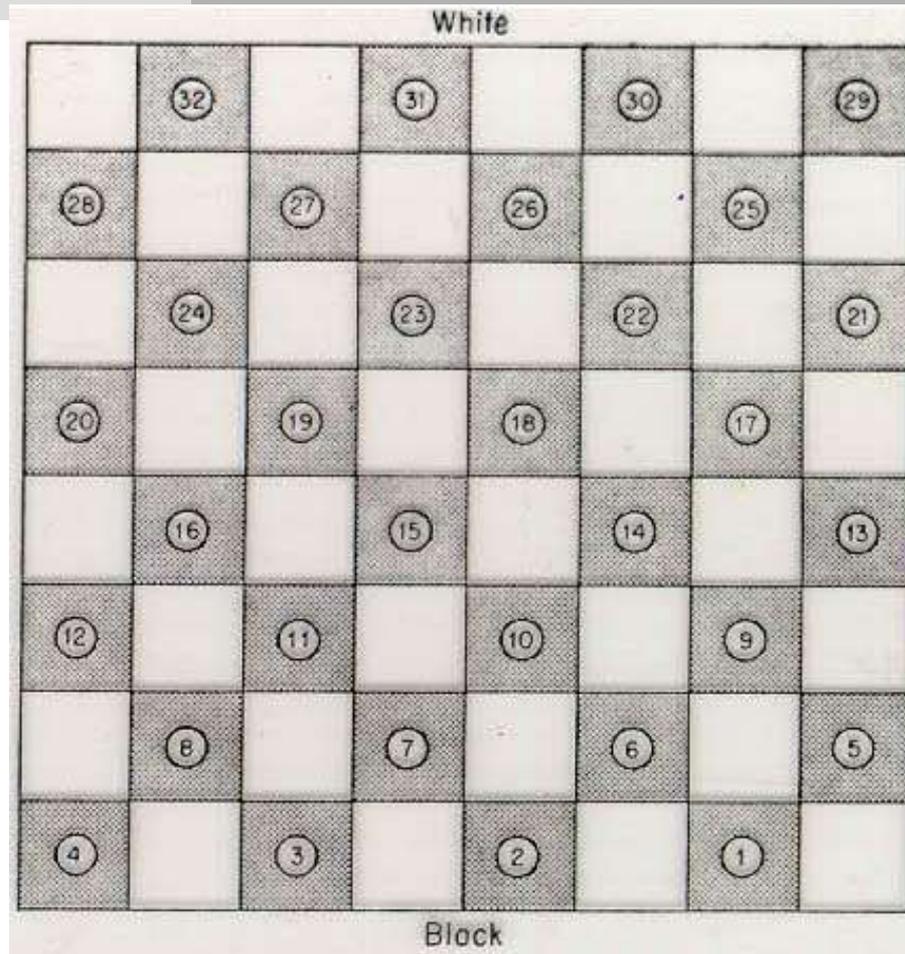


... used in reporting games
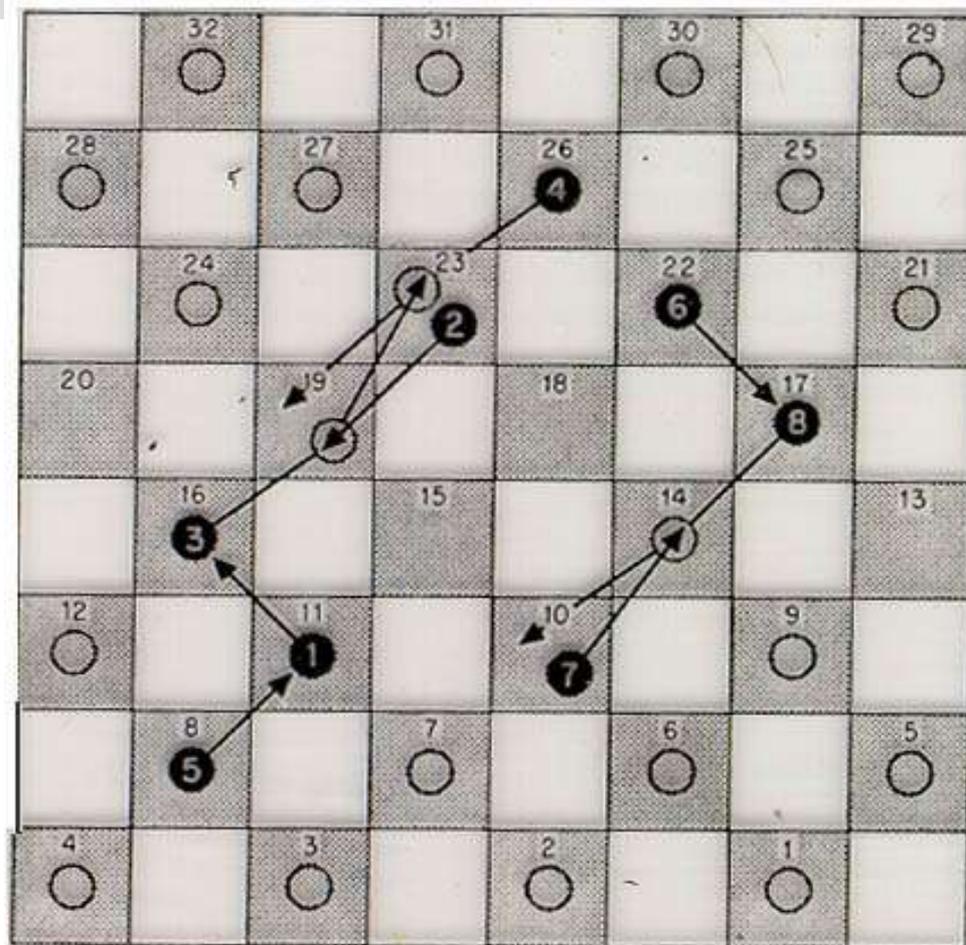
... using generalization learning

- Normal look ahead: 3 moves
- Expanded look ahead: 4 moves, if one of the following:
  - 1. the next draw is a skip
  - 2. the last draw is a skip
  - 3. a catch  is possible
- Expand look ahead to 5 moves, if 1. and 2. fulfilled
- Expansion of look ahead to at most 11 moves if there are further skips. STOP as soon as a skip is not possible!
- Look ahead stops altogether  at 20 moves
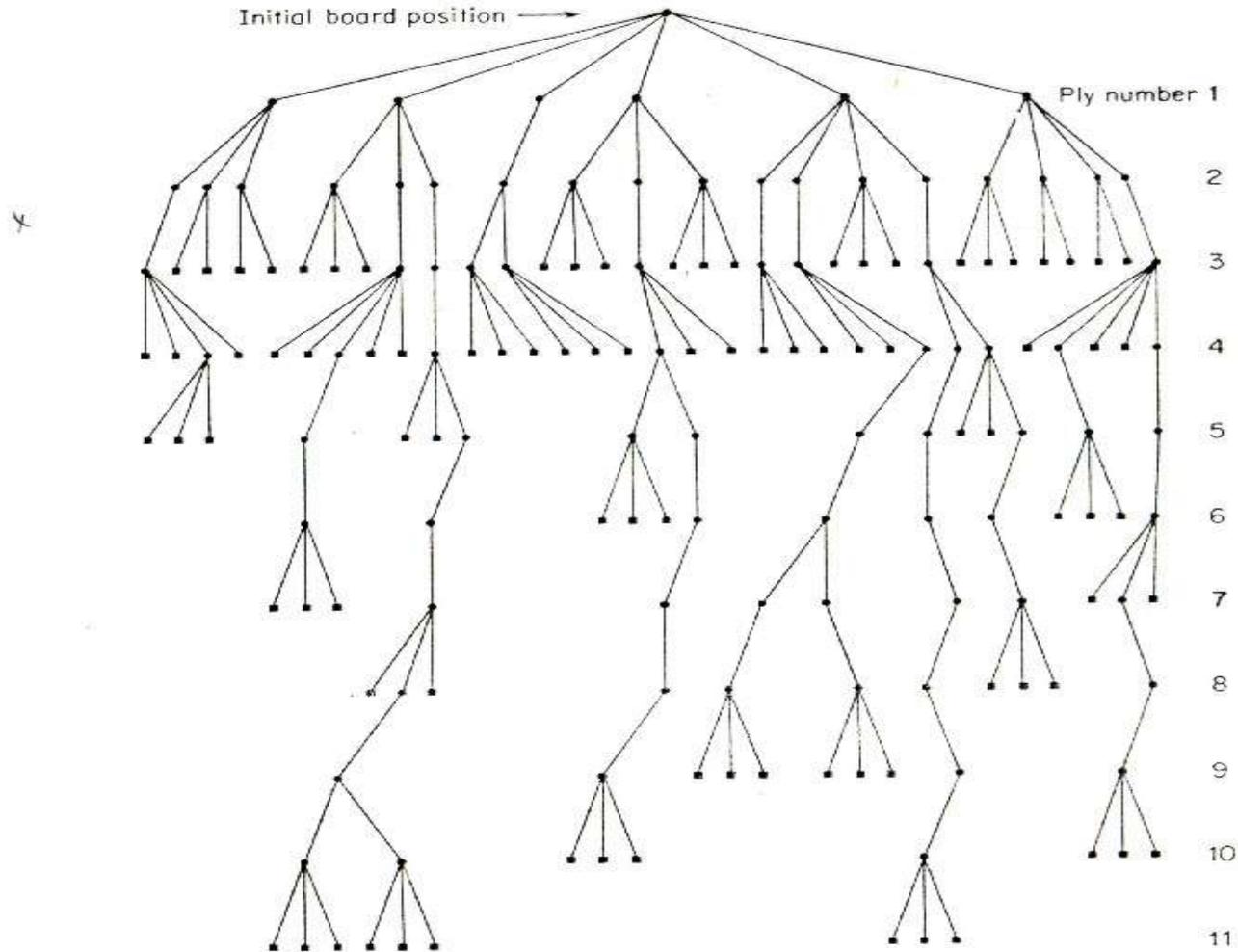
The cut-off branches are further evaluated:

- ➢ If the number of the stones falls below a certain bound

- ➢ Evaluation during tape search

1.  <u>Mate</u>: no (further) move is possible

2.  <u>Advantage of pieces</u>:

    numerical evaluation with ratio 'kinged' pieces : normal = 3 : 2

3.  <u>Polynomial evaluation function</u>:

$$\text{Value} = \sum_i \mu_i p_i$$

$\mu_i = \text{weight}$

$p_i = \text{Parameter}$

**ADV**     **(Advancement):** the parameter increases by one for each passive pieces in the 5$^{th}$ and 6$^{th}$ row and decreases by one for each passive piece in the 3th and 4$^{th}$ row

**APEX**     **(Apex):** the parameter decreases by one if no king is on the board if an active piece is not on squares 7 or 26 and if no passive piece is placed on the other squares

**BACK**     **(Back Row Bridge):** the parameter increases by one if no king is on the board and the squares 1 and 3 or 30 and 32 are not occupied by passive pieces

**CENT1** **(Center Control 1):** increases by one for each passive piece on the the squares 11, 12, 15, 16, 20, 21, 24 and 25.

**CENT2** **(Center Control 2):** increases by one for each active piece that is or can be moved on the squares 11,12, 15, 16, 20, 21, 24 and 25.

**CORN** **(Double-corner Credit):** increases by one if the passive side is dominant and the active player can move into one of the double corner.

**DENY** **(Mobility Increase):** increases by one for each piece that can be taken (without exchange) so that the mobility increases.

**DIA** **(Double Diagonal File):):** increases by one for each passive piece that stays on the diagonals to the double corner.

**EXCH** **(Exchange):** increases by one for each square that can be occupied by one of the active pieces and causes an exchange.

**DYKE** **(Dyke):** increases by one for each 3 pieces respectively that stay together diagonally.

**ADV   (Advancement)** the parameter increases by one for each passive figure in the $5^{th}$ and $6^{th}$ row and decreases by one for each passive        figure in the 3th and $4^{th}$ row

**APEX (Apex)** the parameter decreases by one, if no dame is on the …., if an active figure is not on fields 7 or 26 and if no passive figure is placed on the other fields

**1. Rote Learning: Memorizing**

- <u>remembering</u>: explicit storage of all games including their parameters

- <u>forgetting</u>: "age-factor":

    - +1 after 20 moves

    - *1/2 after each access

    - delete everything above a certain threshold: > min

- <u>searching</u>: semantic hash values:

    - number of pieces                    - queen on the board

    - advantage of the piece           - topological information

- greater and deeper look ahead

- better parameter values

- directionality: i.e. the "will" to win!

    for example: end game

        - all are winning positions

        - all are known

$\Rightarrow$ solution: parameters value minus play depth

## 2. Parameter Weights

- <u>book games</u>

    - in-built and fixed

    - parameter adjustment



    L: number of bad moves

    H: number of good moves

- <u>grandmaster games</u>

    - compare queen-master vs. programme

$\forall$ <u>$\Delta$-adjustment</u>

      - back-up value against actual value

      $-\Delta$ positive:       positive factors $\downarrow$

                   negative factors $\uparrow$

- <u>ALPHA-BETA games</u>

      - ALPHA-programme

      - BETA-programme

      - $\Delta$-adjustment with ALPHA against BETA

            after each game

            while playing

      - as soon as ALPHA is definitely stronger: SWITCH

## 3. Selection of Parameters

- 16 polynom parameters

  22 reserve parameters

$\Rightarrow \Sigma$ 38 parameters

- discovery of new parameters
- "big bang" against local maxima

## 4. Combining Parameters
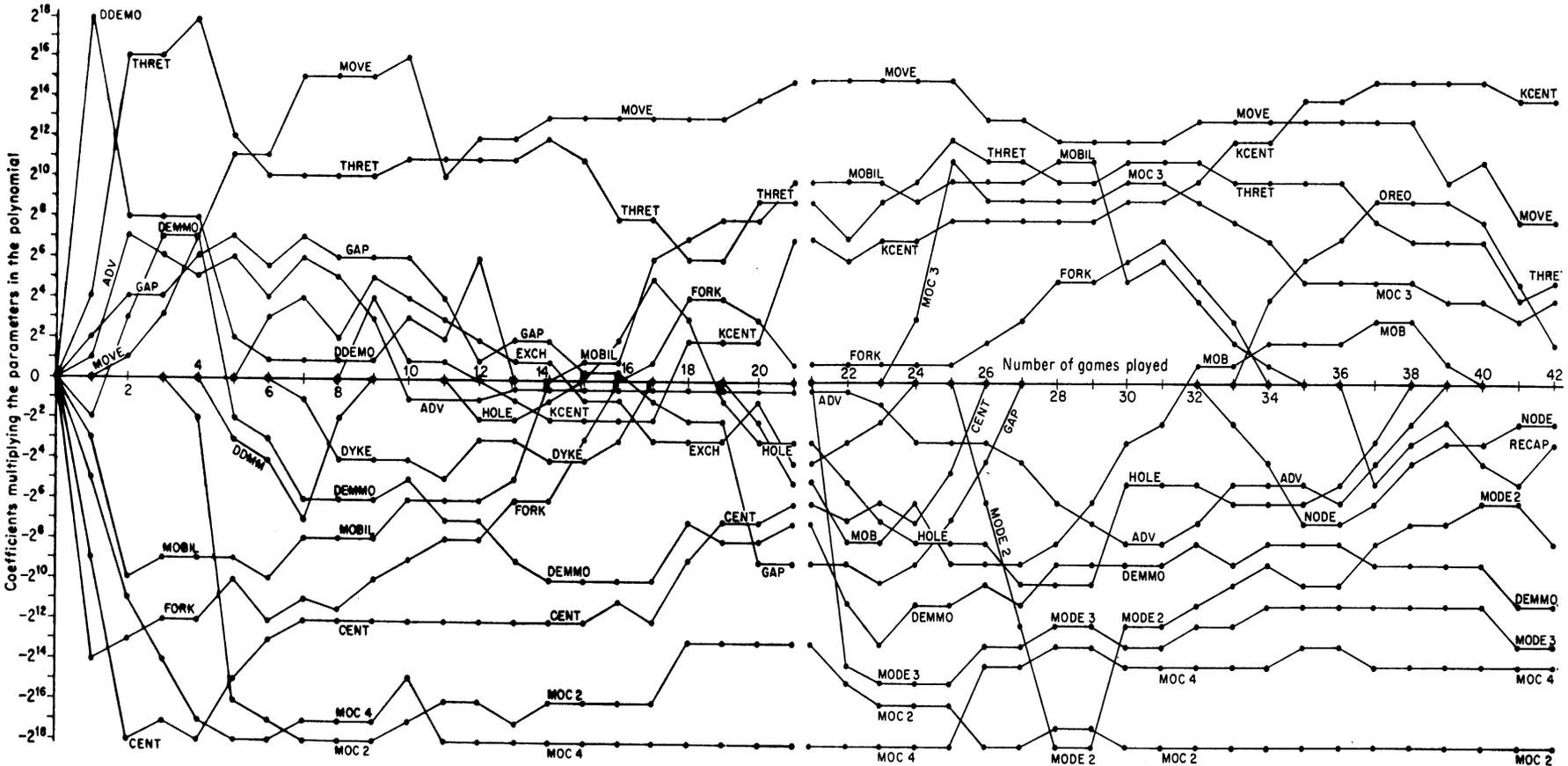
$\wedge$ and

$\vee$ or

$\neg$ not　　　　　　etc.

# Game of Checkers: Test results

Our game . . . did have its points. Up to the 31st move, all of our play had been previously published, except where I evaded "the book" several times in a vain effort to throw the computer's timing off. At the 32-27 loser and onwards, all the play is original with us, so far as I have been able to find. It is very interesting to me to note that the computer had to make several star moves in order to get the win, and that I had several opportunities to draw otherwise. That is why I kept the game going. The machine, therefore, played a perfect ending without one misstep. In the matter of the end game, I have not had such competition from any human being since 1954, when I lost my last game.