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DECUS NO. FOCAL8-9

TITLE HEXAPAWN

HEXAPAWN

DECUS Program Library Write-up DECUS No. FOCAL-9

INTRODUCTION

The object of this program is to have the computer "learn" to play a game, called Hexapawn.

Hexapawn is played on a square board:

O	O	O
X	X	X

Each player has three pawns. A pawn can move forward to an empty space or diagonally forward to capture an opponents pawn. One wins by having any one of his pawns reach the opponents side of the board, by making it impossible for the opponents pawns to move, or by capturing all of the opponents pawns.

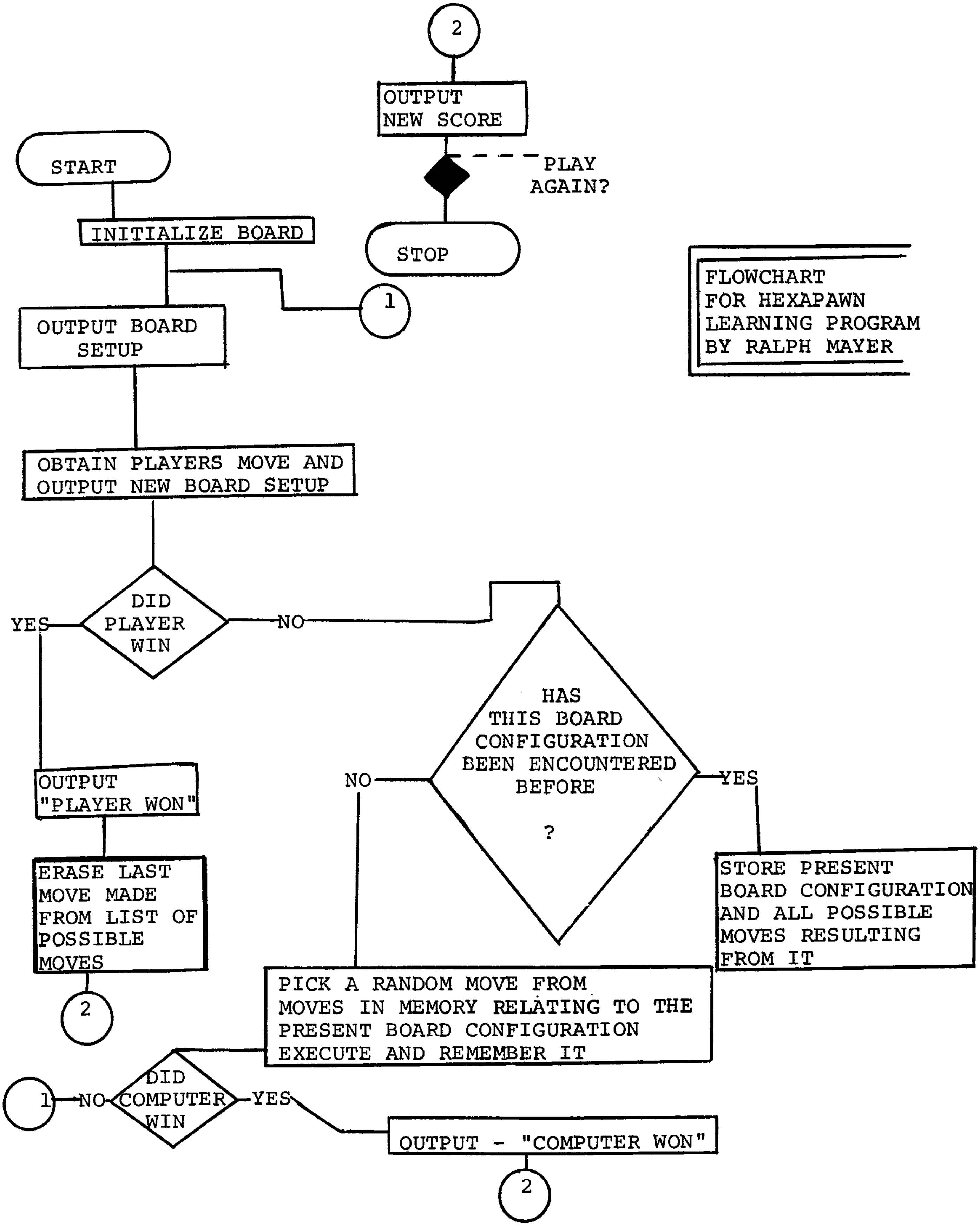
The computer "learns" to play this game by remembering each of the possible board configurations when it is encountered during a game, and then determining and remembering all of the possible moves applicable to each board configuration. Each time the computer has to make a move, the present game board is compared with all the different board configurations in memory. If the present board is identical to, or the inverse of, a board in memory, the number of the similar case in memory is remembered. If the present board configuration or its inverse was not previously encountered, a new case is stored as well as all the possible moves resulting from it. Then the program picks a random move from the moves applicable to the case number of the present board setup. The move is then checked to see that it is not a losing move, and then is executed and remembered. If the computer loses, it next goes back and sets the last move made equal to zero; this action identifies that move as a losing move. Then, if this move is picked again in another game, it will be found to be zero, the program will reject it, and another move will be picked. Thus, when playing a number of games, all "bad" moves will eventually be eliminated one-by-one until the computer is making only "good" moves. At this time the computer will have 14 to 19 cases and will have lost 10 to 16 games, depending on how well the user plays.

Game boards and moves are remembered in the following way: Each of the nine board positions has a value of Ø (empty), 1 (computer), or 2 (player pawn). They are stored as B_1 - B_9.

Each time the program encounters and stores a new board configuration two sets of variables are defined: the board itself is stored using nine variables. The subscript is 10 times the number of the case plus the number of the board position (eg. D12 means case 1, board position 2). The number of sets depends upon the number of cases. The value of the variable is a 0, 1, or 2 (see above). Also, for each case, all possible moves are stored using the same type of subscript. There is a set of these variables corresponding to each. The initial value of these variables is computed as 10 times the initial position of the computer pawn plus the new position of the computer pawn, each position being represented by a number from 1-9.

All these variables can be output in such a way as to be recorded on paper tape and reloaded into the computer using 'DO 13.' However, step 1.1 must be erased or altered to prevent the erasing of all the variables when the program is initialized.

This program can be run on any of the PDP-8 computers with 8K FOCAL. Execution time depends on the user, as the computer gives almost immediate response.



FLOWCHART
FOR HEXAPAWN
LEARNING PROGRAM
BY RALPH MAYER

START
INITIALIZE BOARD
1
OUTPUT BOARD SETUP
OBTAIN PLAYERS MOVE AND OUTPUT NEW BOARD SETUP
DID PLAYER WIN
YES
NO
OUTPUT "PLAYER WON"
ERASE LAST MOVE MADE FROM LIST OF POSSIBLE MOVES
2
HAS THIS BOARD CONFIGURATION BEEN ENCOUNTERED BEFORE ?
NO
YES
STORE PRESENT BOARD CONFIGURATION AND ALL POSSIBLE MOVES RESULTING FROM IT
PICK A RANDOM MOVE FROM MOVES IN MEMORY RELATING TO THE PRESENT BOARD CONFIGURATION EXECUTE AND REMEMBER IT
1
NO
DID COMPUTER WIN
YES
OUTPUT - "COMPUTER WON"
2
2
OUTPUT NEW SCORE
PLAY AGAIN?
STOP

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Ø1.Ø1 C PROGRAM HEXAPAWN BY RALPH MAYER
Ø1.1Ø E
Ø1.2Ø T "THIS PROGRAM PLAYS A GAME CALLED HEXAPAWN",!!,"DO YOU "
Ø1.25 A "NEED INSTRUCTIONS? ",W,!!;I (W-155),2.1;T "THE GAME "
Ø1.27 T "IS PLAYED ON A THREE BY THREE BOARD NUMBERED AS BELOW"
Ø1.3Ø T !!,"1 2 3",!,"4 5 6",!,"7 8 9"!,!,"WE EACH START OFF WITH"
Ø1.35 T " THREE PAWNS-MINE ARE O'S; YOURS ARE X'S",!,"THEY "
Ø1.4Ø T "MOVE LIKE PAWNS IN CHESS. THEY CAN MOVE FORWARD"
Ø1.45 T " TO AN",!,"EMPTY SPACE OR DIAGONALLY TO TAKE ANOTHER "
Ø1.5Ø T "PAWN. YOU",!,"WIN BY REACHING THE OTHER SIDE OF THE "
Ø1.55 T "BOARD OR BY MAKING IT",!,"IMPOSSIBLE FOR THE OTHER "
Ø1.6Ø T "PLAYER TO MOVE.",!,"I AM PROGRAMMED TO LEARN SO IF "
Ø1.65 T "YOU WIN AT FIRST DON'T WORRY-",!,"I'LL SOON CATCH UP."
Ø1.7Ø T !!,"                    GOOD LUCK",!!!!

Ø2.1Ø F X=1,3;S B[X]=1;S B[X+3]=Ø;S B[X+6]=2
Ø2.2Ø D 1Ø;S W1=Ø;S W2=2;S W3=1;D 3;I (-J4)2.3,2.4,,
Ø2.3Ø S SP=SP+1;S C[K]=Ø;T "YOU WON THE LAST GAME",!!
Ø2.35 T "SCORE IS",!!,"  ME       YOU",!,%3.Ø,SC,"     ",SP,!!
Ø2.37 A "DO YOU WANT TO PLAY AGAIN?",W,!!;S J=1;I (155-W)2.1;Q
Ø2.4Ø D 6;T "MY TURN",!!;I (-J1)2.5;S YT=YT+1;S L=YT;D 8
Ø2.5Ø S J1=1Ø*L;D 12;I (-FABS(J4-1))2.6;D 5
Ø2.6Ø S W1=6;S W2=1;S W3=2;D 3;I (J4),2.2;C
Ø2.7Ø D 11;S SC=SC+1;T "I WON THE LAST GAME",!!;G 2.35

Ø3.1Ø S J4=Ø;S J1=Ø;F X=1,3;D 3.7
Ø3.2Ø I (-J1)3.5;F X=1,9;D 3.8
Ø3.3Ø S J4=1;I (J1),3.5;S J2=1;I (1-W2)3.4;S J2=-1
Ø3.4Ø F X=1,J1;D 4
Ø3.5Ø R
Ø3.7Ø I (-FABS(B[X+W1]-W2))3.5;S J4=1;S J1=1;S X=3
Ø3.8Ø I (-FABS(B[X]-W3))3.5;S J1=J1+1;S T[J1]=X

Ø4.1Ø S G=T[X]+3*J2;S J3=Ø;D 4.5;S J3=W2
Ø4.2Ø S G=T[X]+4*J2;I (9-G)4.3;I (G-1)4.3;C
Ø4.25 I (FABS(G+T[X]-1Ø)),4.3;D 4.5
Ø4.3Ø S G=T[X]+2*J2;I (FITR((G-1)/3)-FITR((T[X]-1)/3)),3.5;D 4.5;R
Ø4.5Ø I (-FABS(B[G]-J3))3.5;S J4=Ø;S J1=X;S X=9

Ø5.1Ø S J4=J4+1;F X=1,3,7;S J1=B[X+2];S B[X+2]=B[X];S B[X]=J1

Ø6.1Ø S N=Ø;S J4=Ø;S M=Ø;S J1=Ø;I (-YT)6.2;R
Ø6.2Ø F Z=1,YT;S J2=Ø;F X=1,9;D 7
Ø6.3Ø I (-J1)7.9;D 5;S J1=Ø;I (-M)7.9;S M=1;G 6.2
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07.10 S Y=10*Z+X;I (FABS(B[X]-D[Y])),7.2;S X=9;R
07.20 S J2=J2+1;I (9-J2),7.3;R
07.30 S J3=0;S L=Z;S Y=Y-X;S J1=1;F W=1,N[L];D 7.8
07.40 S Z=YT;I (-J3)7.9;S C[K]=0;S J1=0;S N=1;R
07.80 I (C[Y+W]),7.9;S J3=1;S W=N[L]
07.90 R

08.10 S J2=10*L;S J1=0;F X=1,9;S D[J2+X]=B[X];D 9;S N[L]=J1

09.10 I (-FABS(B[X]-1))9.4;S G=X+3;S J3=0;D 9.5
09.20 S G=X+4;S J3=2;I (9-G)9.3;I (FABS(X-3)),9.3;D 9.5
09.30 S G=X+2;I (FITR((G-.5)/3)-FITR((X-.5)/3)),9.4;D 9.5
09.40 R
09.50 I (-FABS(B[G]-J3))9.4;S J1=J1+1;S C[J2+J1]=10*X+G

10.10 D 11;T "YOUR TURN",!!;I (-J)10.25;C
10.11 T "WHAT IS THE PRESENT POSITION OF THE PAWN YOU WANT"
10.12 A " TO MOVE",X,!!;I (-FABS(B[X]-2))10.7;A "TO WHAT"
10.20 A " POSITION DO YOU WANT TO MOVE IT",Y,!!;G 10.3
10.25 A "FROM ",X,!!;I (-FABS(B[X]-2))10.7;A "TO ",Y,!!
10.30 I (Y-1)10.7;I (X-Y-2)10.7,10.4;I (X-Y-4)10.5,10.45,10.7
10.40 I (-FABS(B[Y]-1))10.7;C
10.41 I (FITR((X-1)/3)-FITR((Y-1)/3)),10.7,10.6
10.45 I (-FABS(B[Y]-1))10.7;I (X-7)10.6,10.7,10.6
10.50 I (B[Y]),10.6,10.7
10.60 S B[X]=0;S B[Y]=2;D 11;R
10.70 T "THAT IS AN ILLEGAL MOVE-TRY AGAIN",!!;G 10.11

11.10 S J1=1;S J2=3;I (J),11.15;T "NEW BOARD IS",!;G 11.2
11.15 T "THE BOARD NOW LOOKS LIKE THIS",!
11.20 T !,"       ";F X=J1,J2;D 11.5
11.30 S J1=J1+3;S J2=J2+3;I (J2-9)11.2,11.2;T !!;R
11.50 I (B[X]-1)11.6,11.7;T "X "
11.60 T "- "
11.70 T "O "

12.20 S J2=FITR(FABS(FRAN()*N[L])-.01)+1
12.30 I (C[J1+J2]),12.2;S K=J1+J2;S X=FITR(C[K]/10)
12.40 S Y=C[K]-X*10;S B[X]=0;S B[Y]=1;I (-N)12.5;R
12.50 F J2=1,N[L];S C[J1+J2]=0

13.10 T "S YT",YT,!;F Z=1,YT;S J1=10*Z;D 14

14.10 T !;F X=1,9;T "S Y",X+J1,"; S D[Y]",D[X+J1],!
14.20 T !,"S Z",Z,"; S N[Z]",N[Z],!
14.30 T !;F X=1,N[Z];T "S Y",X+J1,"; S C[Y]",C[X+J1],!
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