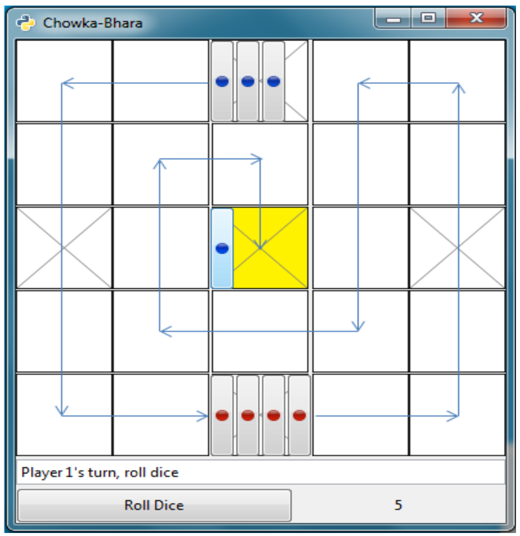
Chowka Bhara – Game of Dice



Objective

"To implement an optimal strategy for a computer player in this partly stochastic, partly strategic Game of Dice"

References of this game are in some ancient Indian epics like the Mahabharata

Setup
- 5 x 5 board
- 2 – 4 player game
- 4 pawns per player
- Objective: All 4 pawns reach the goal square

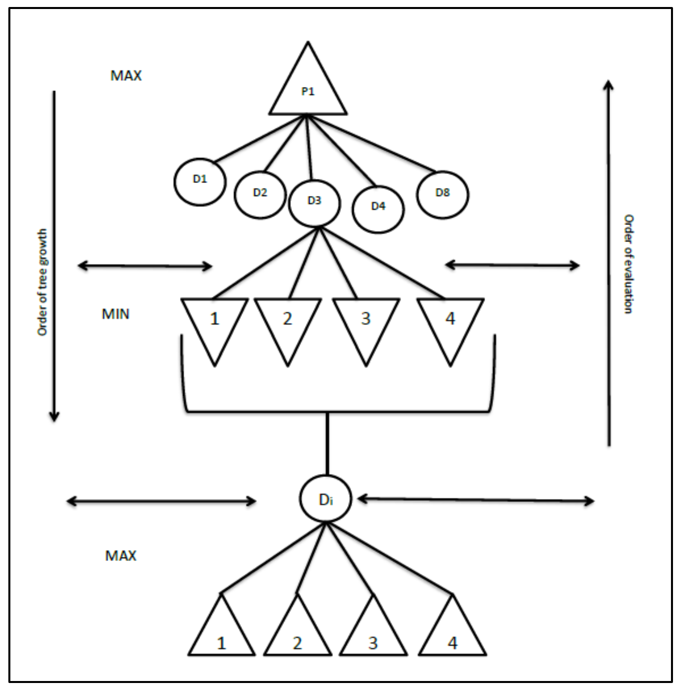
Rules
- Dice values: 1, 2, 3, 4, 8
- Hit: Pawn hit goes back 'Home'
- Safe houses: Pawns cannot get 'Hit' here (X)
- Double: 2 pawns of same player in the same box. Opponent pawns cannot move beyond this Double. A Double can 'hit' a single pawn but a single pawn cannot 'hit' a Double.

Related Work

- Several variations of the game online implemented as Java Applets and NodeJS without AI Component
- Flash implementation with a weighted tree mechanism
- MINIMAX: A classical adversarial search algorithm typically used for two-player zero-sum games.
- EXPECTIMINIMAX: An extension of MINIMAX taking into account the element of chance.
- CHANCEPROBCUT: Pruning of chance nodes, applied in a partially observable game like Stratego.
- Improved alpha-beta pruning of heuristic search in Game trees

Approach – Selecting a Pawn

- Naive Agent A1: Weighted tree approach
- Intelligent Agent A2: using EXPECTIMINIMAX algorithm



- Random Agent A3

Approach – Defining Heuristics

Factors Considered

- F1: Will moving of this pawn hit an opponents pawn?
- F2: Will the pawn move onto a safe house?
- F3: Will the pawn be out-of-reach of an opponent?
- F4: Will it result in the formation of a double?
- F5: The closeness of the pawn in reaching the goal
- F6: The closeness of a pawn in reaching the safesquare
- F7: Number of remaining pawns on the board for the player

Heuristic Functions

- An attacking strategy
  H1: $w1 * f1 + w2 * f2; w1 > w2$
- H2: $(w1 * f1 + w3 * f3) * f7 / f5;$
  $w3$ = distance of the closest opponent pawn
- H3: $f1 / f6$
  Tradeoff between an attacking and defensive strategy,
- H4: $(w1 * f1 + w2 * f2 + w3 * f3) / (w5 * f5 + w6 * f6)$
  $w1 > w2 > w3.$
  $w6 < w5$
  Holistic Heuristic

Results & Interpretation: Algorithms

Table I: Intelligent vs. Random

Heuristic	Intelligent	Random	Moves
H1	44	6	113
H2	40	10	107
H3	37	13	121
H4	47	3	111

Table II: Naïve vs. Random

Heuristic	Naïve	Random	Moves
H1	43	7	116
H2	43	7	102
H3	31	19	142
H4	41	9	117

AI agents trump Random Agent!

Avg. Moves(games won by AI) << Avg. Moves(games won by Random) =>

Random wins by chance

Table III: Intelligent vs. Naïve

Heuristic	Intelligent	Naïve	Moves
H1	25	25	118
H2	22	28	100
H3	40	10	164
H4	27	23	117

- Is a search algorithm better than a weighted tree approach? YES!
- Will the Intelligent Agent be able to perform better if it is able to look deeper into the game tree? By extrapolation: YES!

Results & Interpretation: Heuristics

Table IV: Naive vs. Naïve for each heuristic

Player 1	Player 2	P1 won	P2 won	Moves
H1	H2	27	23	116
H1	H3	42	8	163
H1	H4	33	17	116
H2	H3	36	14	126
H2	H4	31	19	112
H3	H4	16	34	138

H1>H2>H4>H3

Table V: Intelligent vs. Intelligent for each heuristic

Player 1	Player 2	P1 won	P2 won	Moves
H1	H2	28	22	139
H1	H3	33	17	170
H1	H4	32	18	146
H2	H3	26	24	120
H2	H4	23	27	114
H3	H4	27	23	126

H1>(H2~H4~H3)

- Heuristics that combine attacking and defensive strategies perform better than purely attacking/defensive strategies
- Weights really matter!
- It is possible to achieve higher winning rates by altering the weights

Results & Interpretation: Time & Space

Table VI: Time taken/move

Algorithm	Time/move (in ms)
A1	9.3
A2	198.12
A3	0

Branching Factor: 4 *5 = 20

Time and Space Complexity ~ O(b^d)

Table VII: Number of nodes expanded

Algorithm	No. of nodes expanded
A1	4
A2	4*(4*5)*(4*5) = 1600
A3	0

Future Work & References

- Extend algorithm for 4 player game
- Construct an algorithm that learns the probabilities of winning against the various sequences of dice values generated and alter the weights of the heuristics based on its learning set, similar to a neural net or a genetic algorithm.

References

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