



Artificial Intelligence Project Nine Men Morris AI

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Example Outputs for MiniMax and AB Pruning

*AB Pruning produces savings over MiniMax

Opening Phase				
Ply	Input	Output	MiniMax(Estimation values/count)	AB(Estimation values/count)
5	xxWxWxxxxWxBWBBxxx	WxWxWxxxxWxxWBBxxx	3 / 277230	3 / 11527
5	xWxxxWxxBxxxxxBxxx	xWxWxWxxxxxxxxxBxxx	2 / 431734	2 / 4897
5	BBxxxxWBxxWWxxBWxW	BBxxxWWxxxWWxxBWxW	5 / 309223	5 / 8104
5	xxBxWxBBxBxxWxxxxW	xxBxWxBBWBxxWxxxxW	1 / 187790	1 / 4640

Midgame Endgame Phase				
Ply	Input	Output	MiniMax(Estimation values/count)	AB(Estimation values/count)
4	xxWxWxxxxWxBWBBxxx	WxxxWxxxxWxBWBBxxx	-36 / 74075	-36 / 3517
4	BBxxxxWBxxWWxxBWxW	BBxxxWxBxxWWxxBWxW	-13 / 5956	-13 / 1240
4	xxBxWxBBxBxxWxxxxW	xxBxxxBBWBxxWxxxxW	-36 / 106944	-36 / 2500
4	WWBBBBxWxxxxWBWxWx	WWBBBBxWxxxxWBxxWW	1992/3501	1992 / 392

Example Outputs for MiniMaxBlack

Opening Phase						
Ply	MiniMax Input	MiniMax Output	MiniMax(Estimation values/count)	MiniMaxBlack Input	MiniMaxBlack Output	MiniMaxBlack(Estimation values/count)
5	xxWxWxxxxWxBWBBxxx	WxWxWxxxxWxxWBBxxx	3 / 277230	xxBxBxxxxBxWBWWxxx	BxBxBxxxxBxxBWxxx	-3 / 277230
5	xWxxxWxxBxxxxBxxx	xWxWxWxxxxxxxBxxx	2 / 431734	xBxxxBxxWxxxxWxxx	xBxBxBxxxxxxxWxxx	-2 / 431734
5	BBxxxWBxxWWxxBWxW	BBxxxWxWxxWxWxxW	5 / 309223	WWxxxxBWxxBBxxWBxB	WWxxxBBxxxBBxxWBxB	-5 / 309223
5	xxBxWxBBxBxxWxxxxW	xxBxWxBBWBxxWxxxxW	1 / 187790	xxWxBxWWxWxxBxxxxB	xxWxBxWWBWxxBxxxxB	-1 / 187790

Midgame Endgame Phase						
Ply	MiniMax Input	MiniMax Output	MiniMax(Estimation values/count)	MiniMaxBlack Input	MiniMaxBlack Output	MiniMaxBlack(Estimation values/count)
4	xxWxWxxxxWxBWBBxxx	WxxxWxxxxWxBWBBxxx	-36 / 74075	xxBxBxxxxBxWBWWxxx	BxxxBxxxxBxWBWWxxx	36 / 74075
4	BBxxxWBxxWWxxBWxW	BBxxxWxBxxWxWxxBWxW	-13 / 5956	WWxxxxBWxxBBxxWBxB	WWxxxBxWxxBBxxWBxB	13 / 5956
4	xxBxWxBBxBxxWxxxxW	xxBxxxBBWBxxWxxxxW	-36 / 106944	xxWxBxWxWxWxxBxxxxB	xxWxxxWWBWxxBxxxxB	36 / 106944
4	WWBBBBxWxxxxWBWxWx	WWBBBBxWxxxxWBxxWW	1992/3501	BBWWWWxWxBxxxxBWBxBx	BBWWWWxWxBxxxxBWBxBx	-1992 / 3501

*The midgame endgame static estimation function for black has been modified to:
 $(1000 * (\text{num_white_pieces} - \text{num_black_pieces})) + \text{num_white_moves}$
 for symmetry

Example Outputs for MiniMaxImproved

*Produced different output

Opening Phase					
Ply	Input	MiniMax Output	MiniMax(Estimation values/count)	MiniMaxImproved Output	MiniMaxImproved(Estimation values/count)
5	xxWxWxxxxWxBWBBxxx	WxWxWxxxxWxxWBBxxx	3 / 277230	xWxWxWxxxxWxxWBBWxx	62 / 277230
5	xWxxxWxxBxxxxxBxxx	xWxWxWxxxxxxxBxxx	2 / 431734	xWxWxWxxxxxxxBxxx	44 / 431734
5	BBxxxxWBxxWWxxBWxW	BBxxxWxWxxWWxxBWxW	5 / 309223	BBxxxWBxWWWxxWxW	152 / 309223
5	xxBxWxBBxBxxWxxxxW	xxBxWxBBWBxxWxxxxW	1 / 187790	xxBxWxBBWBxxWxxxxW	34 / 187790

Midgame Endgame Phase					
Ply	Input	MiniMax Output	MiniMax(Estimation values/count)	MiniMaxImproved Output	MiniMaxImproved(Estimation values/count)
4	xxWxWxxxxWxBWBBxxx	WxxxWxxxxWxBWBBxxx	-36 / 74075	WxxxWxxxxWxBWBBxxx	27 / 74075
4	BBxxxxWBxxWWxxBWxW	BBxxxWxBxxWWxxBWxW	-13 / 5956	BBxxxWxBxxWWxxBWxW	-27 / 5956
4	xxBxWxBBxBxxWxxxxW	xxBxxxBBWBxxWxxxxW	-36 / 106944	xxBxWxBBxBxxWxxWxx	33 / 106944
4	WWBBBxWxxxxWBWxWx	WWBBBxWxxxxWBxxWW	1992/3501	WBBBxWxxxxWBWWWx	63 / 3501

How Do I Know New Estimation Function Improves

- The new estimation function consider more factors, including
 - The number of closed mills
 - The number of blocked opponent pieces
 - The number of pieces difference
 - The number of two pieces configuration
- When professional players play this game, they will also consider these things for their next moves.
- I wrote a test program called 'AlvsAl.py' (It is included in my homework submission). In this program, one player uses the improved estimation function and the other uses the original one. The game is started from a blank board. Two players will take turn play opening phase and then midgame endgame phase. No matter the player with improved estimation function plays first (white) or second (black), he will win the game.

Reference

- <https://kartikkukreja.wordpress.com/2014/03/17/heuristic-evaluation-function-for-nine-mens-morris/>