

MoHex: Computer Hex World Champion

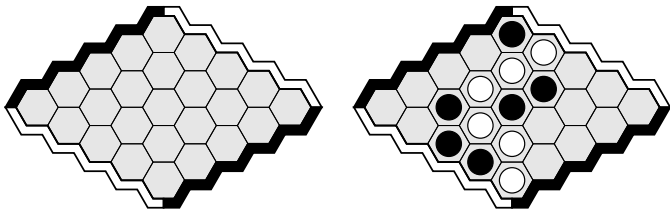
Arneson Hayward Henderson

Comp Sci
U Alberta
Edmonton AB Canada

NSERC/iCORE/UofA GAMES/Schaeffer/Müller

4 Aug 2010

Hex



- properties: $n \times n$, no draw, monotonic, 1pw (swap)
- inferior cells
- connections

- books on Hex by *Cameron Browne*
 - Hex Strategy: Making the Right Connections
 - Connection Games: Variations on a Theme

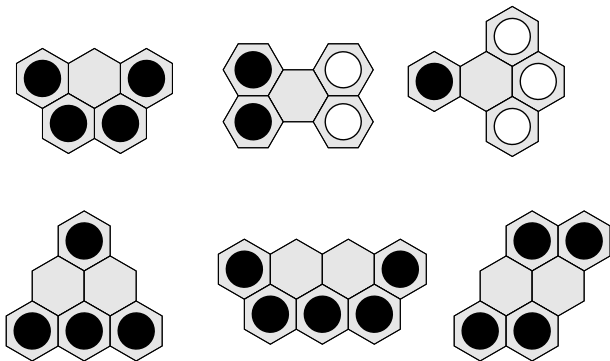
Hex v Go

stones on a grid
connected groups
subgame decomposition
wide branching

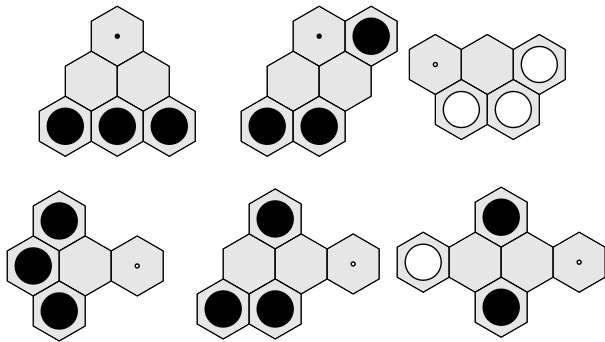
connect
win/loss

territory
score

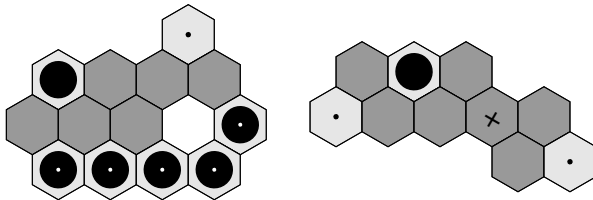
inferior cells: dead/captured



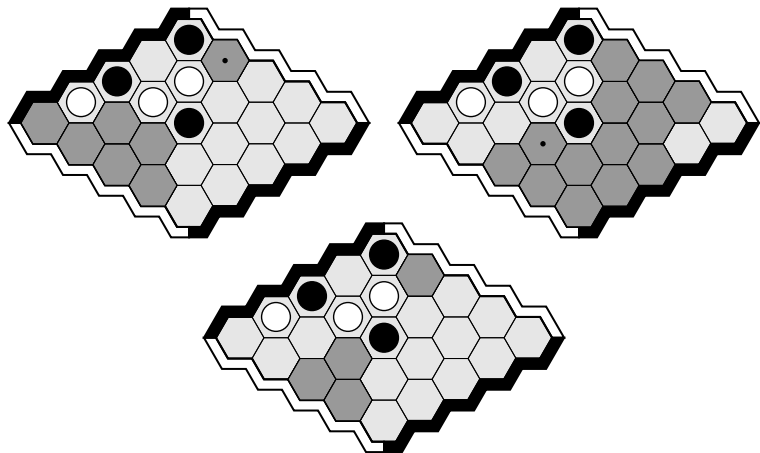
inferior cells: reversible/dominated



connections: VC/SC



connections: mustplay

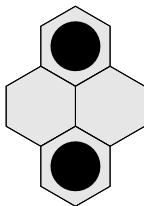


alpha-beta players

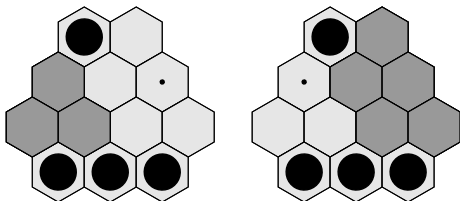
1950	Shannon	(Hex)	circuit saddle point
1950	Shannon	(Bird Cage)	circuit voltage drop
2000	Van Rijswijck	Queenbee	2-distance
2000	Anshelevich	Hexy	circuit + virt'l conn'n
2003	Melis	Six	
2003	H ...	Mongoose	
2008	AHH	Wolve	

MoHex basic framework

- MCTS: tree traversal, game simulation, tree update
- MoHex
 - tree traversal/update: AMAF on, UCT off
 - game simulation: bridge pattern



unused simulation pattern

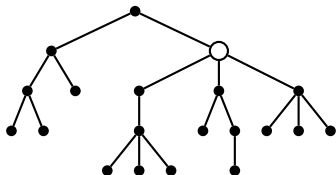


MoHex enhancements: lock-free

- MCTS: lock-free parallelization

MoHex enhancements: tree knowledge

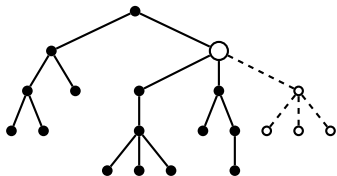
- MCTS: tree knowledge



1. node hits visit threshold: apply ICE/VCE

MoHex enhancements: tree knowledge

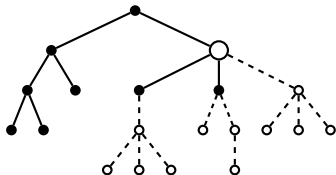
- MCTS: tree knowledge ...



2. prune inferior/non-mustplay children

MoHex enhancements: tree knowledge

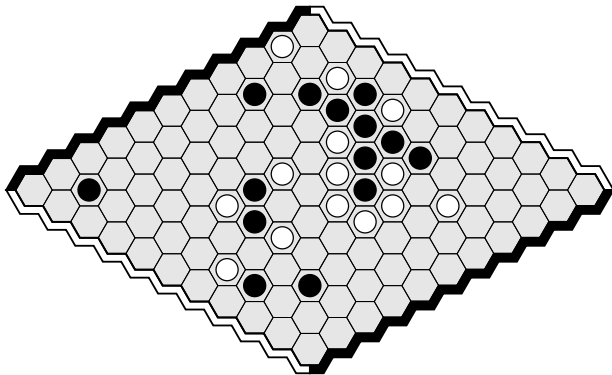
- MCTS: tree knowledge ...



3. remove other children's subtrees

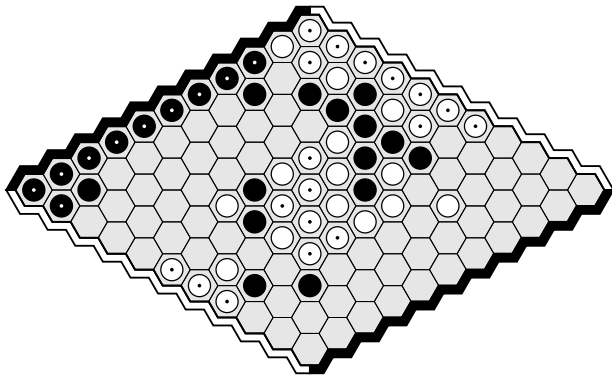
MoHex enhancements: tree knowledge

- tree knowledge: typical position, ICE **OFF** ...

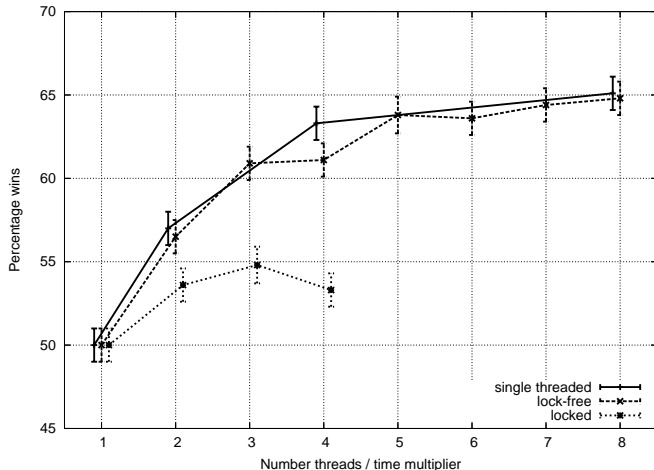


MoHex enhancements: tree knowledge

- tree knowledge: typical position, ICE **ON** ...



exp's: scaling

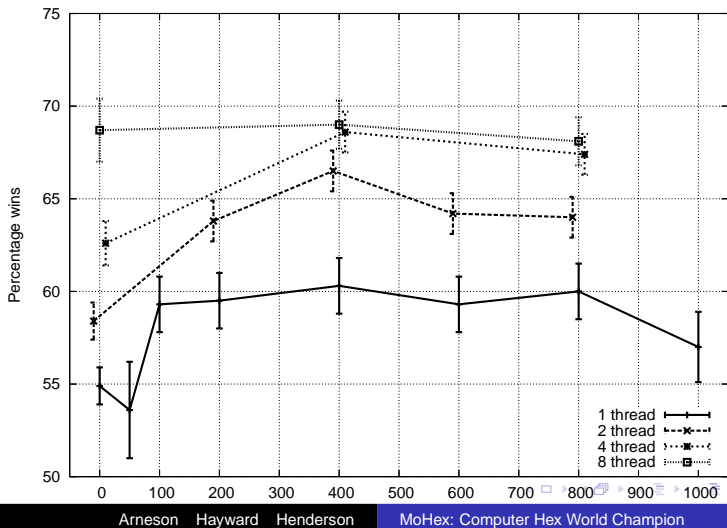


locked/lock-free/time-scaled-1-thread v 1-thread 1s/move

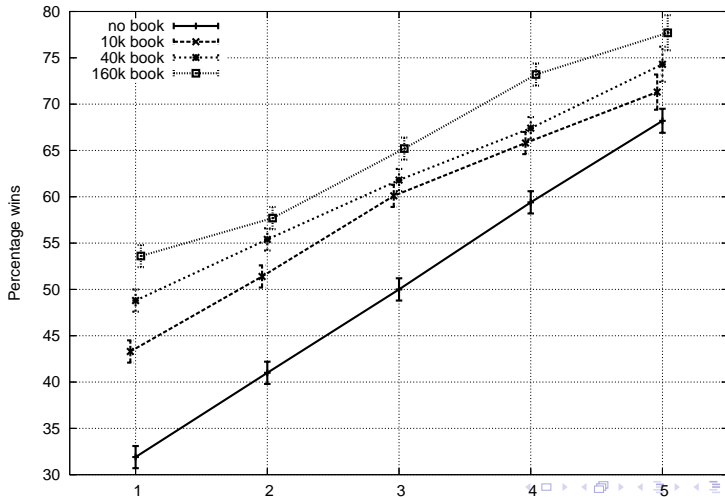
exp's: bridge/AMAF

				win %	Elo gain
bridge	v	—		64.7% \pm 1.4%	105
AMAF + bridge	v	bridge		73.9% \pm 1.3%	181

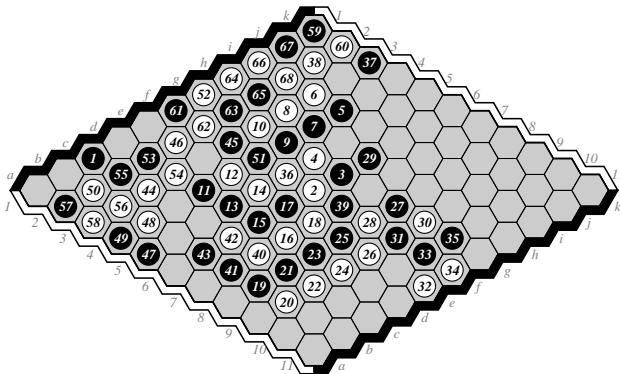
exp's: tree knowledge threshold



exp's: opening book

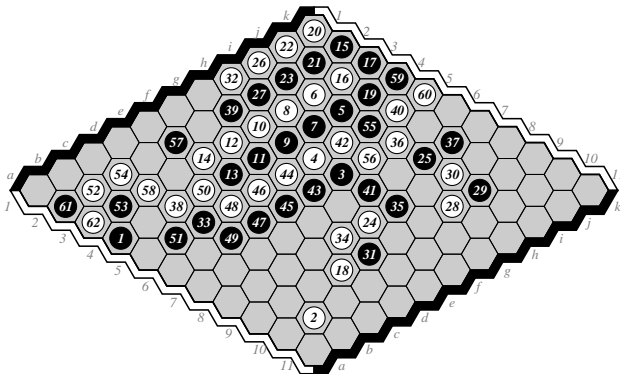


tournaments



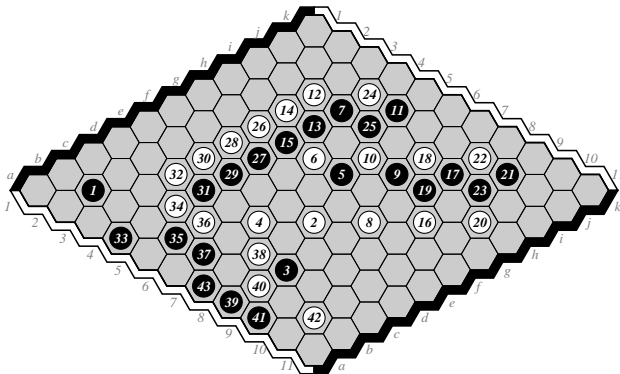
2009: Wolfe v MoHex (white)

tournaments



2009: Six v MoHex (white)

tournaments



2009: Yopt v MoHex (white)

tournaments

Olympiad	gold	silver	bronze	
2009	MoHex	Wolve	Six	Yopt
	6-0	3-3	2-4	1-5
2008	Wolve	MoHex	Six	Yopt
	9-3	8-4	4-8	3-9

242-game rounds	solver/book off
2009	win %
MoHex v Six	76.6 ± 3.6
MoHex v Wolve	49.2 ± 3.2

conclusion

- other games
 - Y
 - Havannah
 - Go
- MoHex todo
 - simulations: connection AMAF
 - tree: solver init'n
- MoHex summary
 - no big surprises