Basic Search Algorithm for Gomoku

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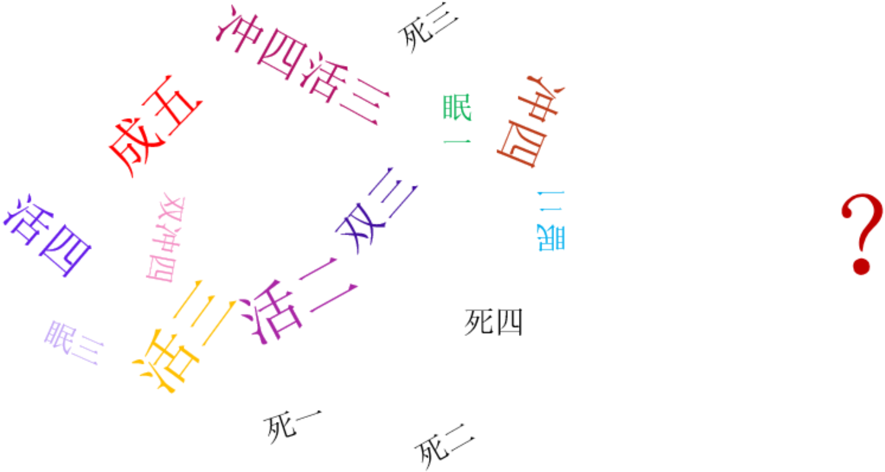
Models



http://587.renju.org.tw/teach/teach017.htm

Into five

- five-connected: The five consecutive chess stones of the same color. Once this type of chess appears, it means that the chess of this color wins.

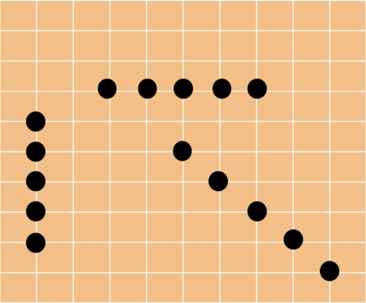
  五连：连续的五个同色棋子的棋型，一旦出现此种棋型，意味着该色棋取胜。

- long-connected: More than five consecutive chess stones of the same color.

  长连：连续五个以上同色棋子的棋型。

- into five: The collective name of five-connected and long-connected.

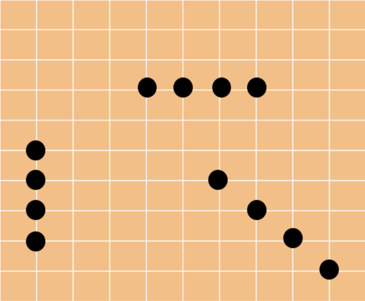
  成五：五连和长连的统称。



Live four

Live four: There are 4 consecutive stones of the same color that are not blocked by the opponent's stones at both ends. It means that there are two positions which can be located stones of the same color to get five stones in a row/column/diagonal line. Once a certain color has such a type, it means the color will win.

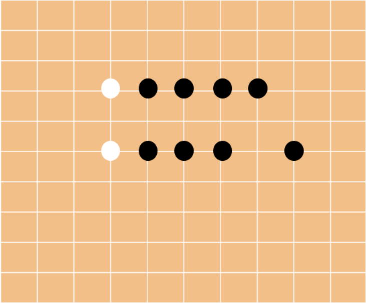
活四：两头没有对方棋子阻挡的连续4颗同色棋子，意味着有两个点落同样颜色子均能五连的的棋型，一旦某色棋出现此种棋型，也意味着该色棋必将取胜。



Flush four

Flush four: Only one position can lead to five-connected type after a fall with the same color. Flush four is not necessarily connected. Sometimes you can use a space to get flush-four according to your needs.

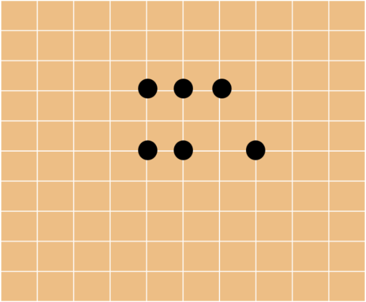
冲四：只有一个点落同样颜色子后能成五连的棋型。冲四不一定是挨着摆的，有时候可以根据需要隔上一个空格来冲四，称为跳冲四。



Live three

live three: A chess type that can become live four after a fall of a stone: categorized as connected-three and jump-three

活三：有落子后能成活四的点的棋型，活三分为连三和跳三。



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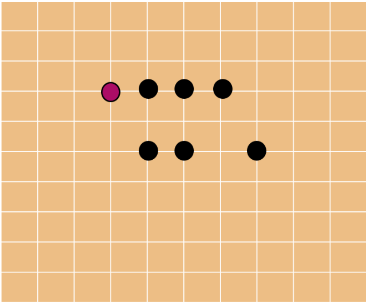

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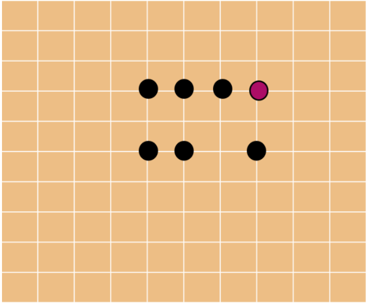

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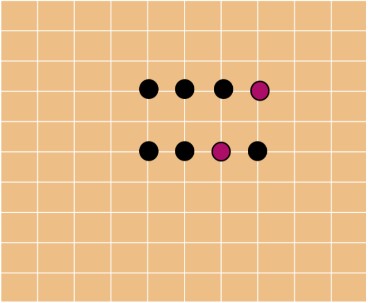
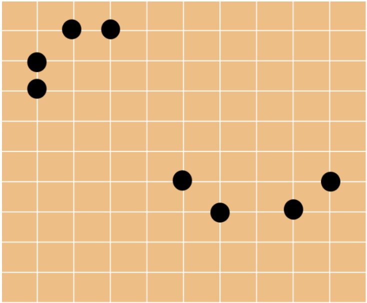


Double three

Double three: A chess type that can lead to two live-three after a fall of stone. It is a chess type that can win.

双三：落一颗子同时形成2个活三。是一种能必胜的棋型。



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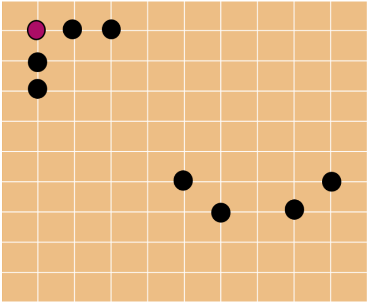

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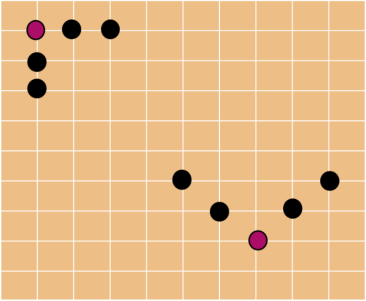
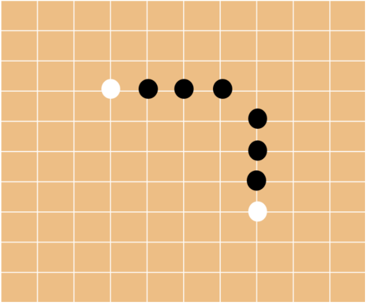


Double flush four

Double flush four: A chess type that can lead to two flush-four after a fall of stone. It is also a winning type.

双冲四：落下一手棋同时形成两个冲四。也是一种必胜的棋型。



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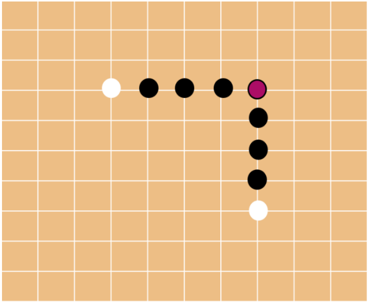

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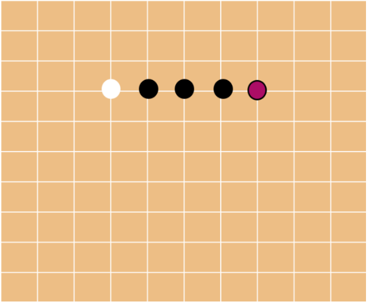

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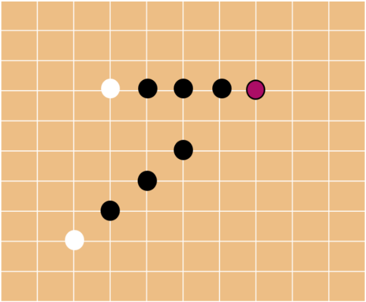
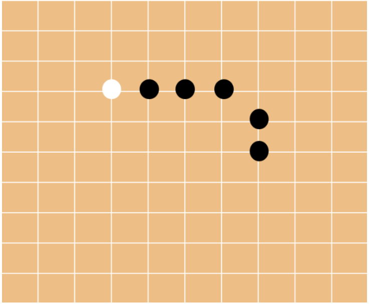


Flush four live three

Flush four live three: A chess type that can lead to a flush-four and live-three. It is also a winning type.

冲四活三：落下一手棋，同时形成冲四和活三。也是一种必胜的棋型。



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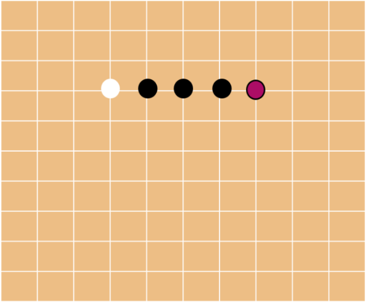

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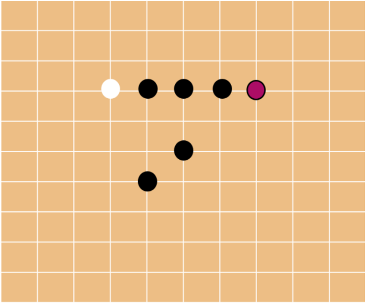
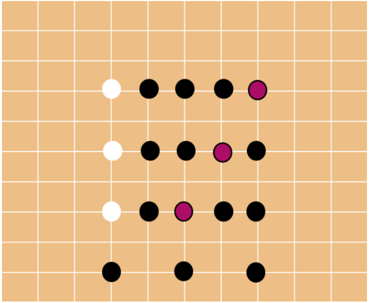


Sleep three

Sleep three: A chess type that can lead to flush-four after a fall of stone. There are many such chess types, which can be divided into several cases.

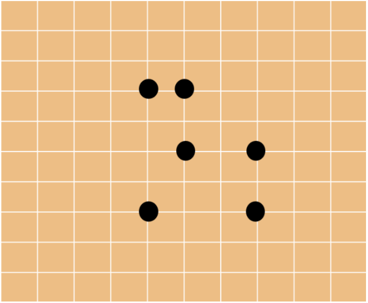
眠三：有落子后能成冲四的点的棋型。 这种棋型很多，分好几种情况。



Live two

Live two: There is a chess type that can lead to live-three after a fall of stone.

活二：有落子后能成活三的点的棋型。



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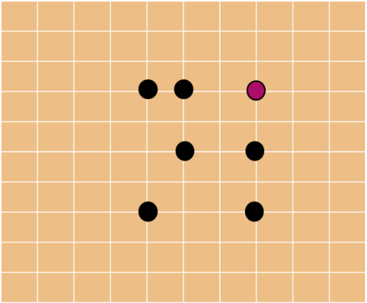

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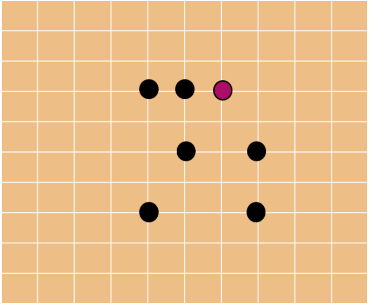

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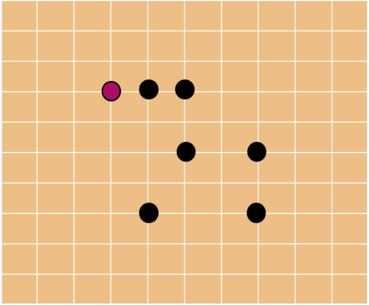

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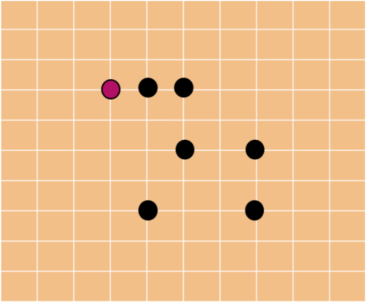

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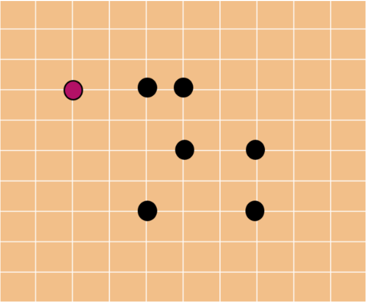

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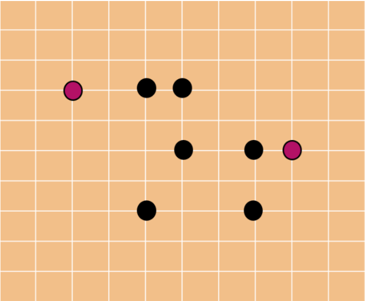

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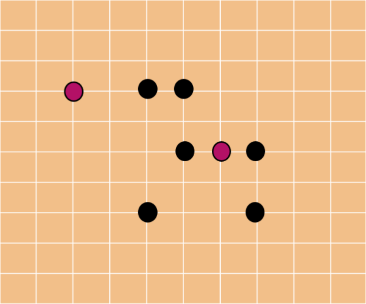

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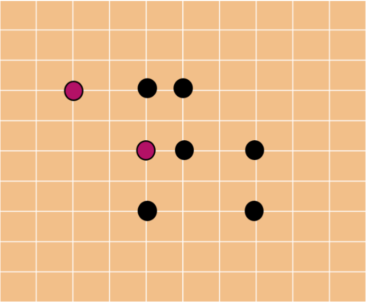

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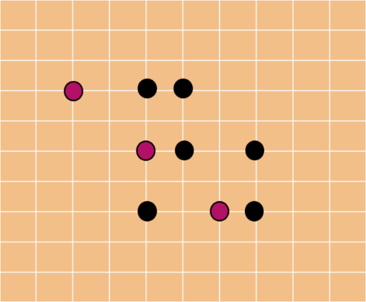

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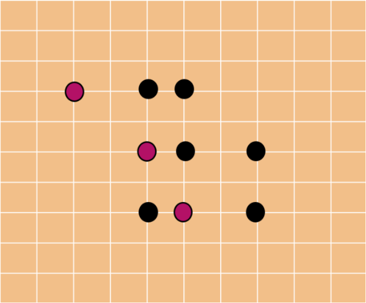
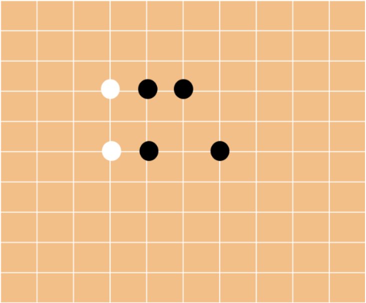


Sleep two

Sleep two: There is a chess type that can lead to sleep-three after a fall of stone.

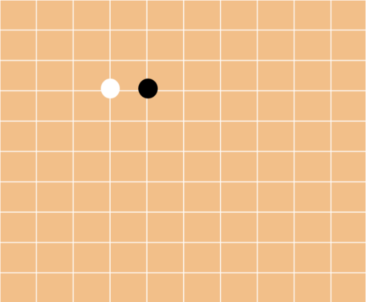
眠二：有落子后能成眠三的点的棋型。



Sleep one

Sleep one: the type of chess that can lead to sleep-two after a fall of stone.

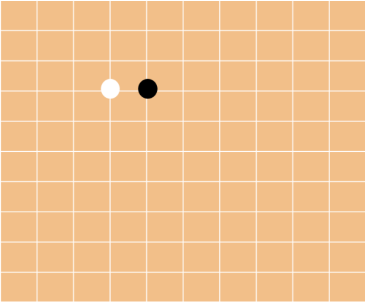
眠一：有落子后能成眠二的点的棋型。



Live one

live one: A chess type that can lead to live-two after a fall of stone.

活一：有落子后能成活二的点的棋型。



Chess type to valuation

- The more favorable the chess type, the more scores it gets. If we form a situation such as five-connected, long-connected, live-four, double-three, four-connected, four-four, which corresponds to a must-win situation, we should assign the maximum score.

  越有利的棋型对应越大的价值，比如五连、长连、活四、双三、四三、四四等，一旦形成就是必胜的局面，应该给予最大的分值

- Secondly, we should assign high scores to the chess type able to create a favorable situation, such as live-three, sleep three, four live two, double two

  其次是用于制造有利局面棋型，比如活三、眠三、四活二、两二等等

- In the vacancy, we should not only evaluate the benefit of white chess but also evaluate the benefit of black chess. If the opponent can get high benefits at a point. We should also try to seize this point to block the maximum benefit of the opponent.

  在空位，不仅要估值如果下白棋的收益，也要估值下黑棋的收益，当敌方在某个位置收益最大，那么也是本方需要抢占的点，即阻断对方的最大收益

Model representation

- You can directly use the notation of Go to represent models, 0 means empty, -1 means black, 1 means white, then 11111 can be used to represent the pattern of five white, and 011110 is used to represent the pattern of four white. Similarly we can get other patterns; the black pattern can be expressed as -1-1-1-1-1 and 0-1-1-1-10.
- Of course, other ways can be used to turn a chessboard into a byte chessboard for players (a binary chessboard, such as 00 for empty, 01 for white, 11 for black). Patterns can be matched in a uniform way.

- 可以直接用*go*的入参数组的表示法，*0*表示空，*-1*表示黑棋，*1*表示白棋，此时可用*11111*表示白棋五连的*pattern*，用*011110*表示白棋活四的*pattern*，其他的*pattern*依次类推；那么黑棋的*pattern*可以表示为*-1-1-1-1-1*和*0-1-1-1-10*。
- 当然也可以用别的方式来存储比如把入参的棋盘转成位棋盘（二进制棋盘，比如*00*表示空闲，*01*表示白棋，*11* 表示黑棋），然后用统一的方式去匹配*pattern*。

Search Range

- The easiest way is to search over a full board. An advantage is the simplicity of processing. A disadvantage is the low efficiency.
- Usually, in order to narrow the search range, we only consider the sub-area with a distance of no more than 4 units from the center of the currently dropped sub-area.

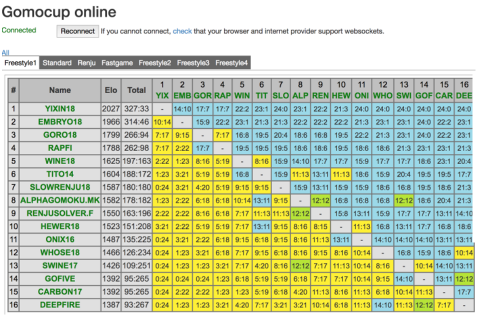
- 最简单的方式为全棋盘搜索，优点是处理简单，缺点是效率低
- 通常为了缩小搜索范围，会考虑以当前已落子区域为中心的不大于4的距离。

Gomocup

- Website: http://gomocup.org/
- Gomocup is a worldwide competition for artificial intelligence in the area of Gomoku. It has been held annually since 2000. As of 2017, it is the largest and most influential AI event for Gomoku in the world, with more than 40 authors from about 10 countries and regions.

  *Gomocup*是五子棋人工智能的世界性比赛。自*2000*年以来，每年举办一次。截至*2017*年，它是国际上最大且最有影响力的五子棋人工智能赛事，有来自约*10*个国家与地区的*40*余位作者参与。

Gomocup Ranklist



Gomocup online

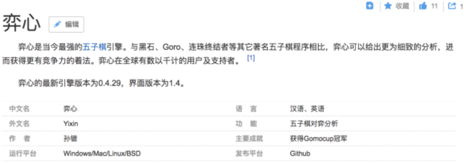
Connected

Reconnect If you cannot connect, check that your browser and internet provider support websockets.

All

Freestyle1 Standard Renju Fastgame Freestyle2 Freestyle3 Freestyle4

#	Name	Elo	Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				YIX	EMB	GOR	RAP	WIN	TIT	SLO	ALP	REN	HEW	ONI	WHO	SWI	GOF	CAR	DEE
1	YIXIN18	2027	327:33	-	14:10	17:7	17:7	22:2	23:1	24:0	23:1	22:2	21:3	24:0	24:0	24:0	24:0	24:0	24:0
2	EMBRYO18	1966	314:46	10:14	-	15:9	22:2	23:1	21:3	21:3	22:2	22:2	22:2	21:3	23:1	23:1	24:0	22:2	23:1
3	GORO18	1799	266:94	7:17	9:15	-	7:17	16:8	19:5	20:4	18:6	16:8	19:5	22:2	21:3	23:1	24:0	22:2	23:1
4	RAPFI	1788	262:98	7:17	2:22	17:7	-	19:5	19:5	19:5	18:6	18:6	19:5	18:6	18:6	21:3	23:1	23:1	21:3
5	WINE18	1625	197:163	2:22	1:23	8:16	5:19	-	8:16	15:9	14:10	17:7	17:7	15:9	17:7	17:7	18:6	23:1	20:4
6	TITO14	1604	188:172	1:23	3:21	5:19	5:19	16:8	-	15:9	11:13	13:11	11:13	18:6	15:9	20:4	19:5	19:5	17:7
7	SLOWRENJU18	1587	180:180	0:24	3:21	4:20	5:19	9:15	9:15	-	15:9	13:11	15:9	15:9	18:6	16:8	19:5	18:6	21:3
8	ALPHAGOMOKU.MK	1582	178:182	1:23	2:22	6:18	6:18	10:14	13:11	9:15	-	12:12	16:8	16:8	16:8	12:12	18:6	20:4	21:3
9	RENJUSOLVER.F	1550	163:196	2:22	2:22	8:16	6:18	7:17	11:13	11:13	12:12	-	15:8	13:11	15:9	17:7	17:7	13:11	14:10
10	HEWER18	1523	151:208	3:21	2:22	5:19	5:19	7:17	13:11	9:15	8:16	8:15	-	11:13	16:8	13:11	17:7	16:8	18:6
11	ONIX16	1487	135:225	0:24	3:21	2:22	6:18	9:15	6:18	9:15	8:16	11:13	13:11	-	14:10	14:10	14:10	13:11	13:11
12	WHOSE18	1466	126:234	0:24	1:23	3:21	6:18	7:17	9:15	6:18	8:16	9:15	8:16	10:14	-	16:8	15:9	18:6	10:14
13	SWINE17	1426	109:251	0:24	1:23	1:23	3:21	7:17	4:20	8:16	12:12	7:17	11:13	10:14	8:16	-	10:14	14:10	13:11
14	GOFIVE	1392	95:265	0:24	0:24	0:24	1:23	6:18	5:19	5:19	6:18	7:17	7:17	10:14	9:15	14:10	-	13:11	12:12
15	CARBON17	1392	95:265	0:24	2:22	2:22	1:23	1:23	5:19	6:18	4:20	11:13	8:16	11:13	6:18	10:14	11:13	-	17:7
16	DEEPFIRE	1387	93:267	0:24	1:23	1:23	3:21	4:20	7:17	3:21	3:21	10:14	6:18	11:13	14:10	11:13	12:12	7:17	-



弈心

弈心是当今最强的五子棋引擎。与黑石、Goro、连珠终结者等其它著名五子棋程序相比，弈心可以给出更为细致的分析，进而获得更有竞争力的着法。弈心在全球有数以千计的用户及支持者。[1]

弈心的最新引擎版本为0.4.29，界面版本为1.4。

中文名	弈心	语　言	汉语、英语
外文名	Yixin	功　能	五子棋对弈分析
作　者	孙锴	主要成就	获得Gomocup冠军
运行平台	Windows/Mac/Linux/BSD	发布平台	Github

- The Gomocup 2018 competition started on April 27 and is now over.
- I hope that excellent students can try to participate in the competition and stand out from the crowd.

Reference—Game theoretic Viewpoint

- A bachelor thesis in 2017
  Application of Game Theoretic Algorithms to Gomoku
- Guidelines: The student will learn the state-of-the-art approximation algorithm for solving large perfect information games–Monte-Carlo tree search and devise its modification suitable for the game Gomoku. He will further enhance this algorithm using heuristic learned by machine learning methods on data containing matches of human players. This algorithm will be used to create the first competitive player of the game Gomoku.
- Abstract: In this thesis, we focus on solving the game Gomoku-swap2. The challenges of this domain are the size of the branching factor and the depth of the game. For this reason, the game cannot be solved exactly and so the evaluation function estimating the quality of a game state is the most important factor. Because it is impossible to solve the game exactly, we use Monte Carlo Tree Search (MCTS) where we use large number of simulations as an evaluation function. To guide the search in the MCTS we use the Neural Network learned on the human-played games.

Reference—Random Forest

- A master thesis in 2012

  Machine Learning for k-in-a-row Type Games Using Random Forest and Genetic Algorithm

- Abstract: The main objective of the thesis is to explore the viability of combining multiple machine learning techniques in order to train Artificial Intelligence for k-in-a-row type games.

  The techniques under observation are following:

  1. Decision Trees
  2. Random Forest
  3. Minimax Algorithm
  4. Genetic Algorithm

Reference—Genetic Algorithm

- Evolving Gomoku Solver by Genetic Algorithm
- Abstract: Classic methods for solving such games are based on game-tree theory, for example the minimax tree. These methods have a clear disadvantage: the depth of search becomes a bottleneck all the time. In this paper we propose a genetic algorithm for solving the Gomoku game. We investigated the general framework for applying genetic algorithm to strategical games and designed the fitness function from various game-related aspects.

Reference—Deep Learning

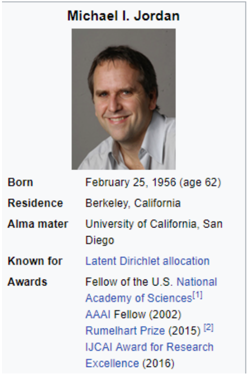
- 2016: Move Prediction in Gomoku Using Deep Learning
- Abstract: With the development of deep learning, move prediction can help to promote the intelligence of board game agents as proven in AlphaGo. Following this idea, we train deep convolutional neural networks by supervised learning to predict the moves made by expert Gomoku players from RenjuNet dataset.

Reference—Recommended Book for Machine Learning

Michael I. Jordan is an American scientist, professor at the University of California, Berkeley and researcher in machine learning, statistics, and artificial intelligence. He is one of the leading figures in machine learning, and in 2016 Science reported him as the world's most influential computer scientist.

论总引用数他不是最高的，但他的很多作品都堪称开山之作。这波*Deep Learning*他没有活跃参与其中，但深度学习领域四大金刚几乎都跟他有关，因此被称为*Deep Learning*影子大佬。他学生中很多已或成为山头，或成为中坚，根繁叶茂，桃李天下。如*Andrew Ng*和*Francis Bach*等。他是谁呢？

他就是人工智能领域泰斗、*Deep Learning*影子大佬、机器学习奠基者、*AlphaGo*们的祖师爷、美国三院院士——*Michael I.Jordan*教授。



Michael I. Jordan

Born	February 25, 1956 (age 62)
Residence	Berkeley, California
Alma mater	University of California, San Diego
Known for	Latent Dirichlet allocation
Awards	Fellow of the U.S. National Academy of Sciences[1] AAAI Fellow (2002) Rumelhart Prize (2015) [2] IJCAI Award for Research Excellence (2016)

Mike Jordan's Recommended Book for Machine Learning