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## Go, going, gone?

Chess has fallen, draughts has been jumped. And a new algorithm has professionals losing the ancient Chinese game to computers for the first time

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It's his Go ... there are hundreds of almost-equal possibilities with each move in the game. Photograph: Myron Davis/Getty

If you want to beat the best software in the world at a classic board game, the only one left to you is the strategy game Go. It's long been considered the last bastion of human gaming superiority, holding out against the onslaught of computational brute force and artificial intelligence techniques, while draughts, Othello, backgammon and chess have all fallen.

But to be a human winner at Go, you're going to have to get good in a hurry. The end, with computers ruling, is in sight.

In February, the software MoGo, developed at the University of Paris-Sud, achieved what was once thought impossible: it won two games, on a 19x19 board, against professional Go players. (It did benefit from a handicap - in effect, a number of free turns at the start of the game.) The same month, a program called Many Faces of Go, with a seven-turn handicap, beat a professional in a game played during the general meeting of the American Association for the Advancement of Science. ([Click here for the human-computer Go challenges page.](#))

The wins did require a lot of computing power, however. MoGo was running on 640 cores of the Huygens supercomputer in Amsterdam; Many Faces of Go on a 32-core 3.2GHz Xeon, eight quad cores networked together.

Next month the bar is likely to rise again as programmers fine-tune their code for the annual [International Computer Games Association](#)

tournament, the computer olympiad, in Pamplona, Spain.

Yet even a few years ago Go looked like an impossible computing task: the "search space" for each move was too big. At each turn, especially in the beginning, there are hundreds of possible places to play (the board has 361 points, compared to chess's 64), and deciding on which will turn out better a number of moves ahead - a comparatively simple task in chess and draughts - turns into a morass, with hundreds of almost-equal possibilities and a few hundred moves over which to compare them. Standard "minimax" methods that work for chess (picking the move that gives your opponent the fewest high-value moves in future) don't work in Go.

### **Across the board**

What's changed has been the development of the UCT algorithm, a special case of the Monte Carlo Tree Search (MCTS) algorithm. UCT first appeared in 2006 applied to small 9x9 Go boards, and now academics, and professional Go programmers, are extending and refining its techniques. It has led to a revolution in Go program development.

David Fotland, the US-based commercial developer behind Many Faces of Go, says the results represent a major leap. But he's realistic about the achievement. "My machine can beat a good amateur, but not a great amateur."

In 2008 he spent six months incorporating UCT into his software, combined with his traditional Go algorithm ("the new algorithm has some blind spots"), and won that year's computer olympiad. At the event every program incorporating UCT beat all the ones using traditional methods.

Go pieces are called stones, are black or white, and identical. Playing alternately, the object is to use one's stones to surround as many blank intersections (called "territory") as possible. Games typically have a couple of hundred moves.

The Go rating scale for amateurs starts at 35 kyu, and moves towards 0: the highest level is 1 kyu. The next amateur rank is 1 dan, up to 7 dan. Above them are professionals, who start at pro 1 dan going up to pro 9 dan, the highest level possible.

"Handicapping" allows weaker competitors to play on a level footing with stronger ones: each difference in grading is given as one stone's start. Thus a 20-kyu player would get nine stones in a game against an 11-kyu player.

Many Faces of Go's result puts it at about a 1-dan amateur ranking. David

Silver, who's researching Go for his PhD at the University of Alberta, says that: "Anyone who would have suggested this [could happen] a couple of years ago would have been laughed out of town."

Silver contributed to MoGo in 2007, developing UCT, which led to the first victories against human pro players on 9x9 boards. But when he started his PhD, pre-UCT, he was discouraged from studying the game by the head of the university's games research group. Too many good minds had been wasted on it, and the research was doomed to failure, it was thought.

### **Game of chance**

For the past 30 years, Go programs have evaluated positions by using handcrafted heuristics based on human knowledge of shapes, patterns and rules. However, professional Go players often play moves according to intuitive feelings that are hard to quantify. Encoding their knowledge into machine-understandable rules has proved to be a dead end.

UCT works on the idea of playing out games over and over again, choosing moves at random, but it is biased to what's been successful before. It does this while still allowing alternative lines to be explored.

Now, Silver says: "I feel very fortunate doing research during this revolutionary period. MCTS is in its infancy, but the rate of performance improvement is pretty rapid." He thinks a machine to beat all humans could appear in four to five years.

Yet humans haven't lost all their tricks. As the human v computer Go challenges page notes: "In every case where each player [computer and human] won at least one game, the human lost the first game played and won the rest. This may be because of experience gained in the first game, or because of techniques learned from discussions with the other players." But the randomisation the UCT algorithm brings may make that result less likely.

Fotland thinks the UCT-based work responds to a certain amount of processor supercharging, but then plateaus. "There is a certain kind of large-scale fighting in Go that requires a kind of thinking the algorithm not good at. [The ranking] 1 dan amateur is where people start being good at these large-scale fights."

### **Wacky races**

His rival Mick Reiss, the commercial programmer behind Go++ ([bit.ly/AnJ9s](http://bit.ly/AnJ9s)), released his version incorporating UCT in Japan this month. His publisher says it matches the Japanese commercial version of Many

Faces of Go in strength.

Reiss doesn't think UCT is the total answer. Of pure UCT-based programs, he says: "A lot of them play in a wacky way, which doesn't really work. Because it's so different to what Go players are used to, in the early games they get beaten. Once they get a bit of practice they get their revenge."

The highest level of his own program is based on a combination of the old-style Go approach and the UCT program. "It does less of the strangeness of the pure UCT programs. It plays in a more conventional way."

Fotland is still circumspect about when computers will dominate Go. "I'd say 20 years. There's got to be several algorithm breakthroughs, and 20 years of Moore's law."

And then? The end of an era? Certainly. But the end of playing Go? Thankfully, as the evidence shows, we still enjoy the simple pleasure of just playing games.

- This article was amended on Friday 1 May 2009. We previously said that a program called Many Faces of Go beat a professional in a game played during the general meeting of the Association for the Advancement of Artificial Intelligence. It was actually during the general meeting of the American Association for the Advancement of Science. This has been corrected.

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