

# Appendix C

## State of the Art Game Playing Programs

### C.1 Introduction

We give some details of recent programs in variety of different types of games for playing two-person games. For some time there have been good programs for playing Backgammon, Othello and Draughts and in fact now there exist programs which are world champion status in all three areas. TD-Gammon has revolutionized the classic game of backgammon. TD-Gammon actually taught itself to play backgammon, starting from scratch, by using breakthrough research in Artificial Neural Networks. TD-Gammon learned to play well enough to rank among the best players in the world. Also Connect-4 and go-moku can be played perfectly by programs.

We begin with Chess, where it has taken quite a while to produce a world-class program.

### C.2 Chess

*Deep Blue* the chess program from IBM beat the world champion Kasparov 3.5 – 2.5 in May 1997. It has special purpose hardware and can evaluate 200 million moves per second. The special purpose hardware clearly helped, but carefully tuned software is also essential.

If we take a typical length game of chess, then there are  $\sim 10^{125}$  possible nodes in the full game tree. This would take more than  $10^{108}$  years to search if  $10^9$  moves could be investigated per second.

*Deep Blue*, uses  $\alpha - \beta$  search using mainly what is called *singular extensions*. It does say a 10 ply  $\alpha - \beta$  search, and then identifies the interesting lines of play to extend the search to a deeper level (say 30 – 40 ply).

It also has other types of extensions. *Threat extension* is used if a position of threat is discovered. *Influence extension* if for example there is a free pawn which can move to become a queen.

The software is used to perform the initial search and then the special purpose hardware for the last 5 ply.

The evaluation heuristic function makes use of a great deal of information such as:

- how good a position is it e.g. difference in number of pieces;
- position of important pieces (e.g. bishop on black is no good if all opponents pieces on white);

*Deep Blue* is compared with grand masters games to tune the evaluation function. Also did some manual tuning by playing against a grand master until poor move identified.

Much of the tree is evaluated in parallel using the 512 special purpose chips with minimal communication.

IBM are interested in exploiting what has been learnt from *Deep Blue* in real world problems. These include such areas as:

- financial risk (using Monte Carlo simulations);
- data mining;
- molecular dynamics simulation – of interest in pharmaceutical modelling (hope to deal with 100,000 atoms.
- use the visualisation tools developed for use in other domains

## C.3 Draughts

*Chinook* is considered the world champion at draughts. It has all end games from 8 pieces pre-computed. This is  $440 \times 10^9$  positions and is compressed to 6 gigabytes. It uses a 25 ply look-ahead tree, and so in the tree soon comes to end positions. Chinook drew with the world champion Tinsley in 1994. He was considered the best champion there has ever been in draughts.

The techniques developed are being used in *BioTools* which is a program for DNA synthesis.

## C.4 Bridge

*Goren-in-a-box* named after famous bridge player Goren. Developed by Ginsberg (who was himself a good bridge player). *GIB* has played in recent American Contract Bridge League – was placed first in the tournament.

## C.5 Scrabble

*MAVEN* trained itself by playing against itself. At a tournament in 1987 it won every game. It uses a 40K American scrabble dictionary together with conjugations of verbs etc. (giving it 90K words).

*MAVEN* changed the way the game is played. The best strategy is go for max points all the time and forget about defensive moves (e.g. blocking opponent from a triple score). It is used to show the best move and all the top players train with it. It is being sold by HASBRO.