A Protocol Study of Problem Solving in the Game of Go

Yasuki Saito and **Atsushi Yoshikawa**
NTT Basic Research Labs.
3-1 Morinosato Wakamiya, Atsugi-shi, Kanagawa Pref. 243-01 Japan
yaski@ntt-20.brl.ntt.jp

Introduction

We started a series of cognitive studies of Go players, mainly using traditional protocol analyses and eye camera (Yoshikawa, 1996). Go player's protocols in real match situations are gathered and analyzed. Our main purpose is to build a model of Go player's problem solving behaviour.

Following characteristics of Go make it one of the best domain to investigate human complex problem solving: (1) Both pattern knowledge and language level knowledge play an important role in Go. (2) Amount and depth of verbalization seems to increase with expertise in Go. Thus we may be able to unravel the secret of high level expertise. (3) Go is becoming a new challenge to AI, and our effort will benefit AI activity to build a strong Go playing programs.

Go Player's Protocols

We connect two players in separate rooms through a program which enables both players to play Go over the computer network. Each player can talk freely without being heard by the other player. We have done twelve matches in total and obtained 2.8Mbytes of protocol data in total. Most significant part of protocols, namely 'naming', 'candidate move generation', and 'lookahead' are gathered and analyzed in depth.

Results

We started our study using simple two box model as our working hypothesis. This model consists of several iterations of 'Candiate Move Generation' and 'Candidate Move Evaluation'. Main results we obtained concerning this model are:

- Number of candidate moves considered per unit is 1.5 in average. Unit is an interval between consecutive moves.
- Candidate moves are generated very quickly, implying that generation is a pattern based process.
- Evaluation can be divided into two categories: **[Quick evaluation]** Without lookahead. This seems to be pattern based. This is used in 80% of units per game. **[Long evaluation]** Using lookahead. Occurring 20% of units per game.
- Lookahead is almost straight. Progressive deepening search in chess (Newell & Simon 1972) also appears in Go. But very few branching occurs in the lookahead. Thus this is quite different from computer program's search. Lookahead depth ranges from 1 to 11, and average depth is 4 (See Figure 1).
- Evaluation at the endpoint of lookahead can also be divided into two cases: **[Pattern based evaluation]** Quick evaluation based on good shape, moyo (large framework of potential territory) etc. **[Language based evaluation]** Many words describing player's own purpose, opponent's purpose, interrelation between multiple purposes all came into play in inferences.

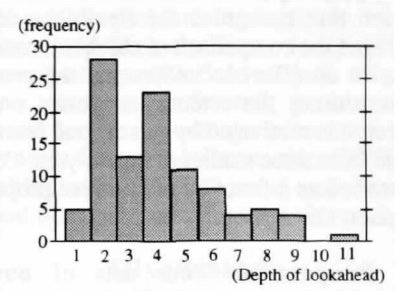

Figure 1: Lookahead depth.

Discussion and Conclusion

Previous work on Chess (Chase, 1973) emphasized the use of pattern knowledge by experts. Go is also full of patterns, but both pattern knowledge AND language level inferences play equally important roles in Go. We found most players use language extensively in their thinking (Saito, 1995). Most important function of language use seems to be search space reduction.

Many findings parallel those of Chess, yet there are significant differences such as the use of language and Go specific terms in Go player's problem solving.

References

Chase, W. G. & Simon, H. A. (1973). Perception in Chess. *Cognitive Psychology*, **4**, pp.55-81.

Newell, A. & Simon, H. A. (1972). *Human Problem Solving*. Prentice-Hall Inc.

Saito, Y. & Yoshikawa, A. (1994). Cognitive study of Go, In *Proc. of the Game Programming Workshop in Japan* (pp.44-55) (In Japanese).

Saito, Y. & Yoshikawa, A. (1995). Do Go Players think in words?, In *Proc. of the 2nd Game Programming Workshop in Japan* (pp.118-127).

Yoshikawa, A. & Saito, Y. (1996). Perception in TsumeGo under 4 Seconds Time Pressure, In *Proc. of the 18th Annual Conference of the Cognitive Science Society*.