

# Implementing an opening book in computer Go

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## Introduction

Implementing a computer program to play the game of Go at master levels has been of great interest to Artificial Intelligence researchers in recent years. Our program Orego has come a long way towards playing a reasonable game of Go, but much progress remains to be made. For example, until recently, our program exhibited poor opening play. Due to the huge number of possible moves at the opening, it is difficult for the program to select a good move.

## Opening Strategy

Computer programs often incorporate human knowledge in opening books to determine strong moves during the early stage of the game. In Computer Chess programs, for instance, opening books may include millions of opening positions.

Previously, opening books for computer Go have used different tactics for storing professional games into a database from which the program would retrieve moves. We took two approaches to storing professional games: a tree of moves and a Hash Map of board positions.



Human Go knowledge is a great advantage in opening play.

## Tree

The first several moves in a collection of professional games were saved into a tree. The top level of the tree represents the set of first moves of the games. The children of each move were the moves that immediately followed the parent move in the game sequence. When Orego moves, if the tree contains the play sequence up to that point, Orego chooses the next move that occurs most often. If the program has exhausted the moves available in the tree, it exits the opening book and commences normal play.

Although the resulting tree provided a reasonable opening book for the program, it was slower than desired. The slow speed was due in part to the vast size of the tree since it included the moves of thousands of games. Also, Orego had to traverse the tree each time it sought a move, which was time consuming.

## Opening Book on the 9x9 Board

In a 9x9 opening, the reasonable set of moves is that which sets up a solid claim on the middle line immediately to gain board influence. When playing with the opening book, Orego takes the reasonable approach rather than playing without regard to gaining influence on the board.

## Opening Book on the 19x19 Board

In the 19x19 opening, the most reasonable approach is that which gains territory in the corners and influence on the rest of the board by playing near the corners and along the 3rd or 4th rows from the edges. Without an opening book, Orego appears to place stones haphazardly, while it exhibits reasonable play with the opening book.

Orego playing itself without the Opening Book

Orego playing itself with the Opening Book

## Rotations/Reflections

To improve the opening book, we accounted for different board configurations that could be produced by simply reflecting and rotating the given board state. The move sequences were reflected and rotated to produce eight distinct move sequences for each game. This rotation and reflection allows us to act as if we saw these additional games in our game collection, and Orego can hence respond to more situations with the opening book.

## Transposition Table

To make the opening book faster, a transposition table was implemented to store the games. In this table, a board condition was linked to the most common response move. One advantage of this structure is that in storing the current board state, the table accounts for the transposition of moves, which prevents the storing of redundant information. Moreover, a board configuration reached by a different sequence of moves than those in the professional games will still be given a good response, while Orego would have had to exit the book with such a sequence in the tree structure. Finally, the table gives the added benefit of increased speed, as Orego needs only submit the current board state to call forth the next move, rather than having to traverse an entire data structure.

## Conclusions

The opening book allows Orego to play much more reasonably in the opening stage of the game. The illogical and sometimes poor opening moves played without the opening book are replaced by good opening plays. Although the win percentage is not significantly different for the 9x9 board (where the opening allows for less variation), we hope to see a higher win percentage due to the opening book on the 19x19 board.

## Future Work

We plan to run more tests on the 19x19 board to verify the usefulness of the opening book. Furthermore, we plan to implement a joseki book. A joseki is a sequence of moves that frequently occurs in the corners during the opening stage of the game, and it results in an equitable trade-off between gaining territory in that corner and gaining influence on the rest of the board. Incorporating these common sequences into our opening book would allow Orego to achieve better play in the corners so that it would enter the middle stage of the game with a better standing. We also plan on testing different lengths for our opening move sequence.

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## For further information

Please contact [drake@lclark.edu](mailto:drake@lclark.edu). More information on Orego and our research can be obtained at <http://legacy.lclark.edu/~drake/Home.html>.