Building a World-Champion Arimaa Program

David Fotland

Smart Games,
San Jose, CA, USA
Fotland@smart-games.com

Abstract. Arimaa is a new two-player strategy game designed by Omar Syed to be difficult for computer players. Omar offers a $10,000 prize to the first program to beat a top human player. My program, BOT_BOMB, won the 2004 computer championship, but failed to beat Omar for the prize. This paper describes the problems with building a strong Arimaa program and details of the program’s design.

1 Introduction

Arimaa is a new two-player perfect-information strategy game designed by Omar and Amir Syed. Their goal was to design a game that was fun to play, and very difficult for a computer to play well. The game has free placement of pieces in the initial position to foil opening books. It has a huge branching factor and long-term strategy, which should make full width search impractical. The game ends with most of the pieces still on the board, eliminating any benefit from endgame databases.

Omar offers a prize of $10,000 for the first program that can beat a strong player (selected by Omar), in a multi-game match with long time limits. The first computer championship was in January, 2004, and was won by my program BOT_BOMB. The computer vs. human championship was played against Omar. He won all eight games, although none was easy, and the average length of the games was 55 moves. Typical Arimaa games last 30 to 40 moves.

Omar contacted me in January, 2003, and suggested I might want to write a program. While I agreed that Arimaa is a more difficult game for computers than chess, I felt I could win the contest. My opinion is that Arimaa is more difficult than chess, but still much easier than Go. It is more like Shogi or Amazons. Even though Arimaa is difficult for computers, Arimaa is a new game, and people are not very good at it yet.

I started in February, and by May BOT_BOMB was the highest rated player at the web site. This May version of the program is still available at the web site under the name BOT_ARIMAANATOR, and is rated about 225 points below the current version. This gain was due to the addition of a goal evaluation and search extensions, and adding the pin evaluation. I stopped working on it over the summer, and in September discovered that the human players had become much stronger. Several new strategic concepts were discovered, and the human players were not blundering away pieces. Several players were rated higher than BOT_BOMB. I worked on the program until the
end of December, but was not able to close the gap. As in computer chess, the program is relatively stronger than people at short time controls. At 30 seconds per move average, the program’s rating is about 100 points higher than the tournament version, with 3 minutes per move.


2 Rules of Arimaa

Arimaa is played on an 8x8 chess board, and can be played with a standard set of chess pieces, although Arimaa renames the pieces Elephant, Camel, Horses (2), Dogs (2), Cats (2), and Rabbits (8), in order from strongest to weakest. Gold (white) starts by placing the 16 pieces in the two rows closest to him\(^1\), in any arrangement, as his first move, then Silver (Black) places pieces on his side of the board. Human play has shown that there are several popular initial arrangements, with different strategic consequences. Silver can place his pieces to counter Gold’s arrangement, which compensates for Gold’s first move advantage. Because all pieces are placed at once, the first move for each side has a branching factor of almost 65 million, so making the first move part of the search is infeasible. There are over \(10^{15}\) possible opening positions, making an opening book infeasible.

After placement, Gold moves first. For each player, a move consists of 4 steps. Each step moves a piece one square horizontally or vertically, except that Rabbits cannot move backwards. The four steps in a move can be used to move one piece or multiple pieces. Any step but the first in a move can be a pass, but the move must change the board position. The goal of the game is to get one of your Rabbits to the 8\(^{th}\) rank.

The board has 4 traps, at the 3-3 squares. After any step, if a piece is on a trap, and there is no friendly piece in one of the four squares next to the trap, that piece is captured, and removed from the board.

Stronger pieces can pull, push, or freeze adjacent weaker enemy pieces. To pull a piece, the player moves a piece one step, then uses another step to move the adjacent enemy piece into the square he just vacated. To push a piece, the player moves an adjacent enemy one square in any direction, then moves his stronger piece into the open square. An adjacent weaker enemy piece is frozen unless it has an adjacent friendly piece. Frozen pieces cannot be moved, although they can still be pulled or pushed.

Repeating a position a third time loses the game. If there are no legal moves available, the player to move loses. The only way to draw is for both players to lose all eight Rabbits.

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\(^1\) In this paper we use ‘he’ when ‘he’ or ‘she’ are both possible.