

A Game of Chess
RANDOM strategy on Baby Chess



1 Introduction

Minichess is a family of chess variants played with regular chess pieces and standard rules, but on a smaller board. The motivation for these variants is to make the game simpler and shorter than standard chess. To play a game of Baby Chess, the board needs to be five squares wide and contain all different chess pieces. In 1969, Martin Gardner suggested a chess variant on 5×5 board in which all chess moves, including pawn double-move, en-passant capture as well as castling can be made. The game was largely played in Italy and the statistics of the finished games are:

- White won 40% of games.
- Black won 28%.
- 32% were draws.

In this Assignment, we shall be considering a simplified version of this two-player game. Please read carefully the game description of Baby Chess. The objective of this Assignment is to analyze the first-mover advantage when both players play the same strategy.

2 Baby Chess

Baby Chess is a two-player game with 10 pieces (per player) which is played on a board of size 5×5 . The game is played with a King, Queen, Rook, Bishop, Knight and 5 Pawns. For a description of each of these pieces, see Table 1. The objective is to checkmate the opponent; this occurs when the opponent's king is in check, and there is no legal way to get it out of check. It is never legal for a player to make a move that puts or leaves the player's own king in check.

2.1 Game dynamics

The game is a two-player (White and Black) game. Both players have 10 pieces, listed in Table 1. The game is played as follows.

- Prior to the first move, both players place their pieces according to the configuration in Figure 1.
- The White player has the first turn.
- Each turn, a player must move a piece to any square which is either free or occupied by a piece of the other player according to the rules provided in Table 1. To avoid a repetition of moves, during the entire game, a piece cannot move backwards. Figure 2 contains some examples of such forbidden moves. Moreover, a piece can switch columns at most 5 times during a game. After a piece has switched columns 5 times during a game, the player may only choose from those moves such that this piece stays in the same column. When a Pawn is promoted to Queen, the new Queen counts as a new piece and as such may switch columns 5 times again.
- When a player moves a piece to a square containing another piece, the player captures this piece and removes it from the board.
- The game ends when: (i) A player *checkmates* the opponent, in this case, the player wins the game, or (ii) when a player has no more viable moves but his King is not in check, the result is a draw and this called a *stalemate*.

Remark: The elements of castling, *en passant* capturing and the possibility of a pawn advancing two squares along the same column are **not** included in this simplified version of Baby Chess.

Pieces	Amount	Description
King	1x	The King moves one square in any direction. The King is the most valuable piece as attacks on the king must be immediately countered, and if this is impossible, immediate loss of the game ensues.
Knight	1x	A Knight moves to any of the closest squares that are not on the same row, column, or diagonal. (Thus the move forms an "L"-shape: two squares vertically and one square horizontally, or two squares horizontally and one square vertically.) The Knight is the only piece that can leap over other pieces.
Rook	1x	A Rook can move any number of squares along a row or column, but cannot leap over other pieces.
Bishop	1x	A Bishop can move any number of squares diagonally, but cannot leap over other pieces.
Queen	1x	A Queen combines the power of a Rook and Bishop and can move any number of squares along a row, column, or diagonal, but cannot leap over other pieces.
Pawn	5x	A Pawn can move forward to the unoccupied square immediately in front of it on the same column. A Pawn can capture an opponent's piece on a square diagonally in front of it by moving to that square. It cannot capture a piece while advancing along the same column. A Pawn has a special power: When a Pawn advances to its fifth row, as part of the move, it is <i>promoted</i> and must be exchanged for the Queen.

Table 1: Piece description of Baby Chess.

3 Questions

We are going to analyze by means of stochastic simulation if this game suffers from a first-mover advantage. For the scope of this Assignment, we shall limit our research to the fixed initial setup given in Figure 1 and the RANDOM strategy.

3.1 Random move strategy: RANDOM

The RANDOM strategy is straightforward. Each turn, the player will select a move uniformly at random from the set of all valid moves. Note that this is different from uniformly at random selecting a piece and uniformly at random choosing a valid move for that piece.

Question 1: Use stochastic simulation to determine the probabilities that a game ends in a win for White, in a win for Black, or in a draw, when both players use the RANDOM strategy. Use sufficiently many runs such that your results are significant.



Figure 1: The initial position of Baby Chess.

Question 2: What is the probability that an arbitrary player promotes a Pawn to Queen during a game?

Question 3: What is the average number of moves until the game ends? And given that White wins the game? For both quantities: How many runs are required to achieve a confidence half-width of at most 0.01?

Question 4: Implement the possibility of a Pawn advancing two squares at once for White. More specifically, a Pawn is able to advance *two* squares along the same column on its first move, provided both squares are unoccupied. Black will always play RANDOM without the possibility of such moves. Repeat Question 1 for this altered strategy and interpret the results.

3.2 Object-oriented approach

Solve the questions using object-oriented programming. Create at least a class for the Simulator, a Game, a Board and Piece and name them accordingly. In your simulation description paragraph, list their relevant attributes, describe clearly how you compute the set of all valid moves, as well as how you encode the memory (as the game progresses, certain moves become invalid).

4 More details

The Assignment will be 25% of the final grade of the course 2DI66. Each groups submission should at least contain:

- A well-written solution containing a title page, simulation description and a result paragraph of **at most 6 pages** (excluding appendix and title page).
- The title page must contain the name and student numbers of all involved group members.
- Include confidence intervals for all of your results.



(a) Backward moving with the Rook.



(b) Backward moving with the Bishop.



(c) Backward moving with the Knight.



(d) Backward moving with the Queen.

Figure 2: Some examples of backward moving in Baby Chess.

- Your appendix should contain your documented source code of your simulation program. Document your code with sufficiently many comments and keep in mind that we have to interpret your code. Add as well a table of the workload distribution within your group.

More detailed guidelines can be found in Canvas, so check the rubric for more information. Urgent questions can be sent to m.a.a.boon@tue.nl and/or p.verleijdsdonk@tue.nl. Upload your report in PDF format before the deadline specified in Canvas. This is a hard deadline! Please include a zip file containing your source code. You can use the object-oriented programming language of your choice. However, the use of external libraries (such as SimPy) is **not** allowed!