COMP3270 Mini Project
Ken Leung

The program has implemented the basic interface for the UCI protocol, so it can connect to GUI chess program, e.g. Arena.

In order to play in the terminal, type “play”.

Instruction for playing in the terminal:

- new game - new
- Moving a piece - move a2a3
- promotion move - move a7a8q (queen), move a7a8r (rook), ...b (bishop), ...n(knight)
- Search move - search depth 5
  search
  search depth 5 timelimit 5000 (millisecond)
  type "s" to stop searching
- undo move - undo
- set vs Mode - vs [on/off] side [white/black] (turn on or off the vs mode, set the play side)
  vs side [white/black]
  vs depth 7 timelimit 1000 (the max. depth and timelimit for the computer rival)
- print the board - print
- set the Position - position [fen | startpos] moves a2a4 a8a7 …(fen: Forsyth–Edwards Notation)
- quit - quit

Piece Symbol:
K: White King, Q: White Queen, B: White Bishop, N: White Knight, P: White Pawn, R: White Rook/Castle

k: Black King, q: Black Queen, b: Black Bishop, n: Black Knight, p: Black Pawn, r: Black Rook/Castle

Castling Permission : K: king side castle, Q: queen side castle

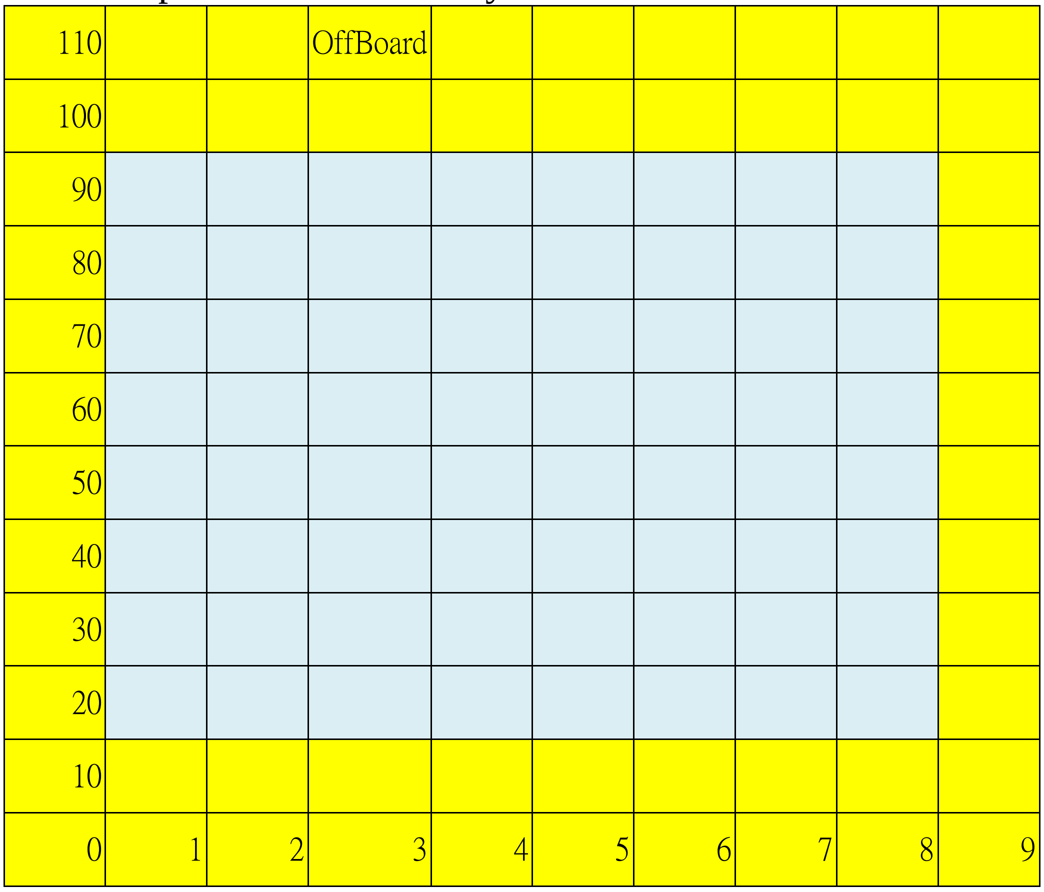
Computer Searching Setting:
default : the time limit of each step is 10 seconds (Max. depth = 30)
You may change them by the above instruction. i.e. vs .....

Compile: (std C++11)
Window: use visual studio to compile
(may need to install Visual C++ Redistributable for Visual Studio 2012 for the dynamic library)
∵ c++11 thread used
OSX: use the makefile

Implementation of the program:

programing language: C++

Board Representation: an array of 120



It stores the number representing the pieces, empty, and offboard.
yellow: offboard area
green : board area

Searching :

using alpha-beta searching with additional heuristics and pruning.

move ordering:

using the iterative deepening to find out the Principal variation(best moves) in the different depth. The depth n search may search the principal variation path of the depth n-1 first because it has the greater chances to be the best path of depth n search and it helps give a better moving order which leads to more beta-cutoff.

Besides, it uses the killer heuristic, history heuristic for non-capture move, and MVV-LVA (Most Valuable Victim - Least Valuable Aggressor) for the capture move to improve the move ordering.

Transposition Table:

Remember the move searched

If the depth in table >= depth in the search, there are three cases to be considered.

case 1: the exact score (alpha < score < beta) stored in the hash table
    simply return score

case 2: the alpha is stored
    if (alpha in table < alpha) return alpha, ∵ no improvement

case 3 the beta is stored
    if (beta in table > beta) return beta, ∵ too good

It reduces the number of nodes.

hashkey : Zobrist Hashing; the number is randomly assigned when starting the program.

∴ the performance of the chess may be different at different time.

Pruning and Move Reduction:

Principal Variation Search:

By assuming it has a good move ordering in the searching, the pv nodes (best moves in the search with alpha < score < beta) would be searched first. The remaining sibling are expected to be the cut-nodes (score >beta), so the exact score of the remaining moves are not important. Therefore, the program use principle variation search to search the remaining nodes in the null window (i.e. beta = alpha +1) because we only care whether the moves can improve alpha and the narrower range of alpha-beta can cause more cut-off. Only if the move improve alpha, the move will be researched in the normal range of alpha-beta to find out the exact score of the move.

In order to increase the speed, it is implemented with null-move pruning, multi-cut, futility pruning, late move reduction despite that it may lose the best path based on the evaluation.

Null-move pruning :

try to perform a null move (move nothing) and search for a reduced depth with [alpha = beta -1, beta=beta], which is trying to see whether the opponent can improve his situation. If the return score >= beta, it means that the current state is very good because even if moving nothing, the opponent still cannot improve his situation. Therefore, the opponent has a great chance to avoid reaching this state, so it can simply return beta.

Multi-cut pruning (used after Null-move pruning):

try to perform first M moves to search for a reduced depth with [beta-1,beta]. If there are scores of C moves >= beta, then return beta. It is because the first few moves should be more significant than the later moves, it has a great chance to have a beta-cutoff in the normal search, so it simply return beta to prune out this node. In order to reduce the error, only score >=beta moves performed by different pieces are counted.

Null-move pruning is a faster way to prune the extremely good node and the multi-cut pruning helps prune the remaining still good enough cutoff-node. It shows a increase in depth in a given time limit.

Futility Pruning:

At depth ==2, evaluation the state score and add it with a potential maximum improvement.

If (score + potential maximum improvement < alpha), simply return alpha because it has very little chance to improve the situation.

Late Move Reduction:

First few moves would be searched with the full depth, and the later moves would be searched with a reduced depth. It is based on the assumption that we have a good node ordering, so the first few moves' scores have a higher chance to > alpha or even >=beta and the later moves' score usually < alpha.

In general, using these heuristic and techniques do increase the searching depth in a given time limit and increase the chance of winning a game (each move in a given time limit) compared to a basic version, though the result might not be the best in the searching due to those pruning and heuristic.

Evaluation function:

- position of pieces (according to the example in the chessprogrammingwiki)
- number of pieces
- isolated pawn
- passed pawn
- doubled pawn (mobility)
- whether a pawn is defended by pawns
- open files for queens and rooks
- dual bishops
- how many big pieces(i.e. rook, queen, bishop, knight) remain
- Insufficient material? Repeated?

Database: None