

Assignment: Game Search

2ID90, edition 2019-2020 Q3

1 Overview

In this assignment you are going to build a computer player for the game of INTERNATIONAL DRAUGHTS. In short¹, International Draughts is a two player strategy game played on a 10x10 board of which only the dark fields are used to initially position 20 white pieces and 20 black pieces. The players in turn move a piece of their own color diagonally over the board. The white player starts the game. Pieces of the opponent may be captured by jumping over them to an empty field². Finally, the player without any remaining moves loses the game. See figure 1 for a picture of a draughts board in the initial position.

You are challenged to write a draughts playing agent that will be automatically graded and the 16 best graded players will compete in an *offline* competition in KILLER DRAUGHTS³. The agent that wins the competition will play a game of INTERNATIONAL DRAUGHTS against a former Dutch champion.

In global terms, you need to

1. write an alpha-beta search algorithm (Section 2),
2. write a function that can evaluate a state of the draughts game (Section 3), and
3. integrate these two in a framework for playing a (computer) draughts tournament (Section 4 and Section 5).

For this to work out you are given some functionality specific to the international draughts game (Section 6).

2 Alpha-beta search

For a general ALPHA-BETA algorithm the following classes/interfaces are useful⁴:

- class GameState with methods:
 1. getMoves(): for getting all valid moves in this state,
 2. doMove(Move): for making a move,
 3. undoMove(Move): for undoing a move.
- class Move, a class encapsulating the data for doing and undoing a valid move in a certain state.
- class GameNode with methods
 1. getGameState(): to return the game state of this node, and
 2. setbestMove(Move) and getBestMove(): to set or get the best move found for the game state of this node.

¹ If this game is unfamiliar to you you can find a full explanation of its relatively simple rules at [wikipedia](https://en.wikipedia.org/wiki/International_draughts).

² A player who can capture a piece, is *obliged* to do so.

³ Killer draughts only differs in the following: during a capture move by a king, this king has to land immediately after the last captured piece, if that piece is a king. This rule considerably reduces the draw margin of the game.



Figure 1: An international draughts board with pieces in initial position. Michel32NI, International draughts, [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/).

⁴ In your implementation they are DraughtsState, Move, and DraughtsNode, respectively. All of them are provided to you.

A rather simple and surely incomplete sketch of an alpha-beta algorithm then becomes something like this:

```

1 int alphaBeta(GameNode node, int alpha, int beta) {
2     GameState state = node.getState();
3     List<Move> moves = state().getMoves();
4     for (Move move : moves) {
5         state.doMove(move);
6         ... // recursive call
7         state.undoMove(move);
8     }
9     node.setBestMove(bestMove);
10    ...
    
```

It should be possible to stop an alpha-beta method call that takes too much time⁵. Technically, this boils down to throwing an exception, after a boolean *stopped* has been set to true in the stop() method:

```

1 private boolean stopped = false;
2 public void stop() { stopped = true; }
3
4 int alphaBeta(GameNode node, int alpha, int beta)
5     throws AIStoppedException {
6     if (stopped) {
7         stopped = false;
8         throw new AIStoppedException();
9     }
10    ...
    
```

⁵ For fair play in the Contest environment of section 4, it is required that the computer players use the same amount of time.

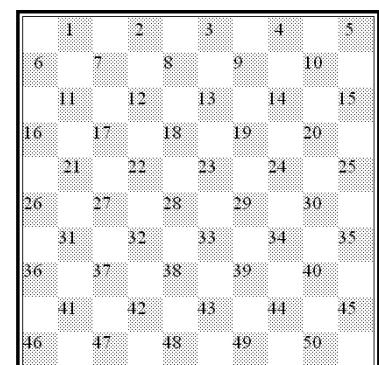
3 Draughts Evaluation function

In leaf nodes of the game tree the state of the game has to be evaluated. To implement an evaluation the state of the game has to be inspected. A simple evaluation might count the number of pieces on the board. A skeleton of an evaluation function is given below. Note that the index of the pieces array starts at index 1; this is conform the International Draughts field numbering that goes from 1 to 50 as shown in figure 2.

```

1 import static nl.tue.s2id90.draughts.DraughtsState.*;
2 ...
3 int evaluate(DraughtsState ds) {
4     // obtain pieces array
5     int[] pieces = ds.getPieces();
6     // compute a value for this state, e.g.
7     // by comparing p[i] to WHITEPIECE, WHITEKING, etc
8     ...
9     return computedValue;
10 }
    
```

Note that the gametree may have two types of leaf nodes: 1) actual leaves without successor states, and 2) nodes at which the maximal search depth is reached. These two nodes need a different treatment.



4 Tournament framework

As you are writing your own AI player you need to test it in the AICOMPETITION tool (see figure 3) against other AI players or

Figure 2: The field numbers used on a draughts board. Initially, the white pieces are on the fields 31-50 and the black pieces on the fields 1-20.

against a human player. In order to do so you need to implement the Player interface by inheriting from the DraughtsPlayer class. From the Player interface you need to implement the getMove(DraughtsState) method, that should return a valid move in the argument game state. Furthermore, a stop method has to be implemented, similarly to the method discussed in section 2. For a player that plays random moves this is very simple as shown in the code below, where the stop method is empty, because the getMove function is almost instantaneous.

```

1 public class RandomDraughtsPlayer extends DraughtsPlayer {
2     public Move getMove(DraughtsState s) {
3         List<Move> moves = s.getMoves();
4         Collections.shuffle(moves);
5         return moves.get(0);
6     }
7     public Integer getValue() { return 0; }
8     public void stop() { }
9 }
    
```

In your own implementation of a strong DraughtsPlayer the getMove method should contain a call to alpha-beta.

To get you quickly on track we gave you a sample implementation of an AI player that already has implemented:

1. calling an alphabeta method;
2. catching and throwing AIStoppedExceptions;
3. handling incomplete searches;
4. returning both best move and corresponding game value to the AICompetition tool.

5 Installation

Two NETBEANS projects and a library folder are provided:

- AICompetition: a project for the AICompetition tool,
- DraughtsPlugin: a project containing an example Draughts player, and
- a lib folder with some additional libraries.

Branding the player project by replacing *NN* by *XY*, *your group's number in canvas*, gives you your own *unique* player project:

1. In the src folder rename package `nl.tue.s2id90.groupNN` to `nl.tue.s2id90.groupXY`⁶.
2. Optionally, rename class `nl.tue.s2id90.groupXY.MyDraughtsPlayer` to a name of your liking⁶; this name will appear in the AICompetition tool.
3. In the arguments options⁷ of the AICompetition project, write `../DraughtsPlugin/dist/`.

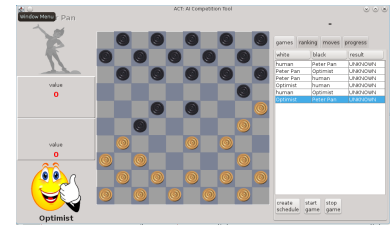


Figure 3: A screenshot of the AICompetition tool.

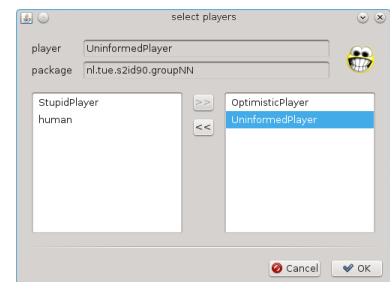


Figure 4: Popup of the AICompetition tool for selecting the players in a contest.

⁶ Do this using the NetBeans functionality for renaming packages/classes, available via the context menu REFACTOR/RENAME.

⁷ The command line options are specified in the run tab of the project properties.

After *first* compiling the AICompetition project and *then* your DraughtsPlugin project, you can run the AICompetition tool. In that tool pressing the CREATE-SCHEDULE button should give you a popup similar to that in figure 4, but then containing your own player.

6 International Draughts Library

The java library file AICompetition.jar contains several classes for International Draughts. Below the source code of some of them is given. The relevant classes and their source code and javadoc are provided.

6.1 Gamestate

This interface is implemented by the DraughtsState class.

```

1 package nl.tue.s2id90.game;
import java.util.List;

3 /** class that keeps the state information of a Game. */
5 public interface GameState<Move> {
    /** @return a list of valid moves in this state. */
    List<Move> getMoves();

    /** @return true iff valid moves in this state exist. */
    boolean isEndState();

    /** applies move m in this state. */
    void doMove(Move m);

    /** undoes the effect of move m. */
    void undoMove(Move m);

    /** @return whether or not the white player is to move. */
    boolean isWhiteToMove();

    /** resets state to initial game state. */
    void reset();
23 }

```

6.2 Player interface

This interface is implemented by the DraughtsPlayer class. Implementations of the latter class may be provided to the AICompetition tool where they can be selected for playing a game.

```

1 package nl.tue.s2id90.game;
import nl.tue.win.competition.util.Identity;
3 public interface Player<Move, State> extends GameState<Move>
    extends Identity {
5     /** computes a valid move in the given game state s.
     * This method should be prepared
     * to immediately return a Move when stop() has been called.
     * @return a valid move in State s.
     */
    Move getMove(State s);

    /** @return the computed value of the last Move.
     * Returns null if that value is not available.
13 }

```

```

15  /**/
    Integer getValue();
17  /** as a result of this call the Player should immediately
    * return a value in getMove().
19  /**/
    void stop();
21  }

```

7 What to do next?

To come to a basic draughts player you need to do the following.

- Implement alpha-beta.
- Implement an initial evaluation function that just counts pieces.
- implement Iterative Deepening.

From here on you can repeatedly try to improve your player in several ways, for example:

- enhance evaluation function.
- improve search function.
- improve stop criterion for searching.
- reuse results in a previous iteration of Iterative Deepening.

Improvements that hinder your opponent are clearly not allowed⁸.

The automatic grader will try to evaluate the above mentioned in order to come to a grade.

⁸ So, it is not allowed to search while the opponent is searching; it is not allowed to keep results between two calls to Player::getMove().