Theory of Computer Games (Fall 2020)
Homework 2

NTU CSIE

Due: 14:20 (UTC+8), December 24, 2020

Outline

1 Game Description

2 Homework Requirements

3 Submission and Grading Policy

Einstein Würfelt Nicht! (Dame)

Game Rules

1. The game is played on a 6x6 board. Initially, there are 6 red and 6 blue pieces located at top left and bottom right consecutively.
2. The initial pieces configuration is random.
3. In a turn, player can move any piece of its own one square forward in one of the three directions closer to the opponent's corner.
4. A player can **capture other pieces** by landing on their square and then replacing them. Note that a player is allowed to capture a piece of its own.
5. A player can pass **if and if only** there is no legal move available

Terminal Condition

The game is over when:

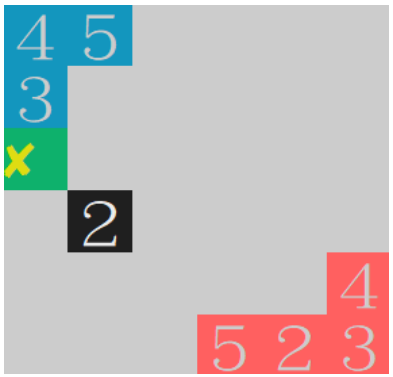
1. If the last red piece is captured, blue player wins
2. If the last blue piece is captured, red player wins
3. If six red pieces reach corner, red player wins
4. If six blue pieces reach corner, blue player wins
5. If all remaining blue pieces **and** all remaining red pieces reach corner,
   - If number of red pieces is greater than blue pieces, red player wins
   - If number of blue pieces is greater than red pieces, blue player wins
   - If number of blue pieces is equal to red pieces, player with highest corner piece number wins
   - If number of blue pieces is equal to red pieces **and** SouthEast and NorthWest corner have the same piece number, then it is a draw

Terminal Condition

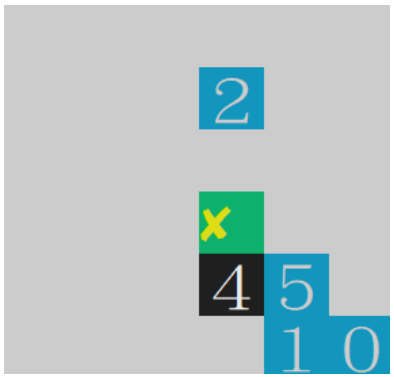
A player has reached corner when all of its remaining pieces:

- Cannot capture opponent's piece
- Cannot move to an empty square

5 Blue pieces at corner
Blue won

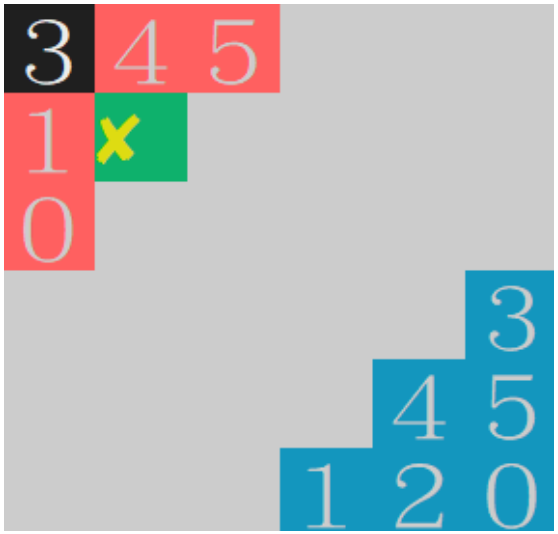


same number of pieces, $4 > 3$
Blue won

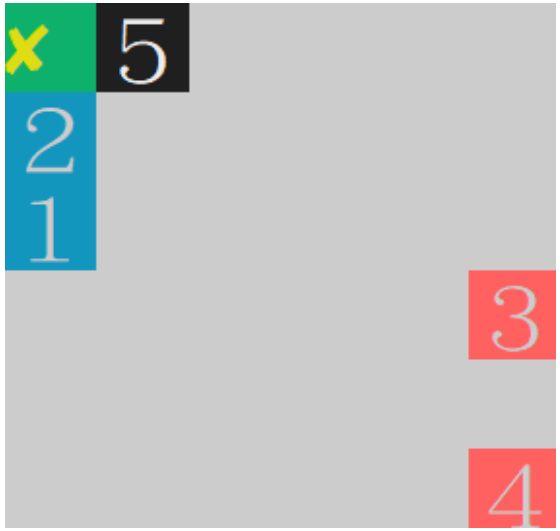


no red pieces left
Blue won

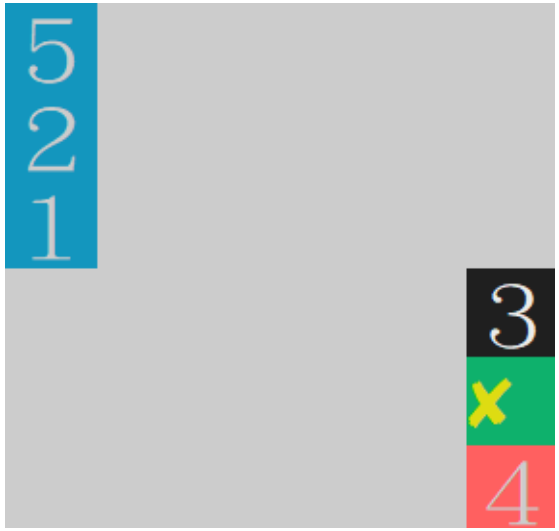
Einstein Würfelt Nicht! (Dame)



Initial board
Red: E, S, SE
Blue: W, N, NW



Blue can only capture its own piece



Blue won!

Let's Play

Compilation

- Run `make` under `hw2` directory.
- It'll generate 4 executables: `game`, `random`, `conservative` and `greedy`.
- `game` is the main gaming environment, while the others are baseline agents.

How to Play

- The game supports AI-AI, AI-human and human-human mode.
- You can choose which mode to play by specifying `[-f]` (first player) and/or `[-s]` (second player).
- For example, the following command runs random and vs human mode

```
$ ./game -f ./random
```

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Requirements

HW Requirements

1. Implement an agent of modified **Einstein Würfelt Nicht! (Dame)** using Monte-Carlo Tree Search.
2. Beat the conservative AI and the greedy AI.
3. Analyze the performance of your agent

Part I: Einstein Agent

Basic Requirements

1. Write an agent that receives opponent's last move (from `game`) and sends move accordingly back.
2. We've handled most parts of the communication. Receive messages by reading from `stdin` and send messages by writing to `stdout`.
3. Read everything character-by-character: if you expect a message of length k, read one character k times instead of directly reading a string of length k.
4. Remember to flush every time after writing a message to `stdout`.

Part I: Einstein Agent (Cont'd)

Basic Requirements

1. You can assume that every move your agent receives is valid.
2. Your agent should send a valid move within 10 seconds. If `game` receives an invalid move, or doesn't receive a move within the time limit, your agent will be killed and your opponent wins immediately.

Message Format

Message Format

R: Received, S: Sent

- R_1: 12 characters that denote initial pieces configuration, e.g. 345120345120 (see illustration)
- R_2: A single character
  - `'f'`: you are the first player
  - `'s'`: you are the second player
- R_3: 2 characters, can be "--" (pass) or *nd* (otherwise), where
  - n = number of piece to be moved
  - d = direction: 0 (vertical), 1 (horizontal), 2 (diagonal)
- S: 2 characters, can be "--" (pass) or *nd* (otherwise) only.

Frame of an Agent

```
1:  while True do
2:      receive R1, R2
3:      B ← Board(R1)
4:      myTurn ← R2 =="f" ? True : False
5:      while True do
6:          if B.terminal() then
7:              break
8:          end if
9:          if myTurn == False then
10:             receive R3
11:             do opponent's move R3 on B
12:         else
13:             choose a move S
14:             do the move S on B
15:             send S
16:         end if
17:         myTurn ←!myTurn
18:     end while
19: end while
```

Algorithms

1. You are required to implement the following algorithms:
   - UCT tree search with tree expansion based on UCB score
   - Add **at least one** of Progressive Pruning (PP) **or** RAVE
2. Singe core, and no more than 4GB RAM
3. You can add plug-in learning + training data, but the training needs to be done by TA in 30 minutes using hardware described above
4. Your agent will be tested by
   `$ ./game -f [your_agent] -s [our_agent] -r 5`

Part II: Agent Performance Analysis

Report Structure

Your report should include but not limited to:

1. Implementation
   - How to compile and run your code in linux. Don't upload the compiled executable file.
   - What algorithm and heuristic you implemented.
2. Experiments
   - Results and findings of your implementation
3. Discussion
   - Observe your refinement on UCT tree search and (PP/RAVE), try to measure the improvements.

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Submission

- Directory hierarchy:
  - student_id // e.g. r08922166 (lowercase)
    - Makefile // make your code
    - src // a folder contains all your codes
    - report.pdf // your report
- Compress your folder into a zip file and submit to https://www.csie.ntu.edu.tw/~tcg/2020/hw2.php.
- Due to server limitation, the file size is restricted to 2 MB.

Grading Policy

1. Beat the baselines (10 points)
   - Beat Simple Conservative Agent (SCA) (5 points)
   - Beat Simple Greedy Agent (SGA) (5 points)
2. Report (5 points)
3. Bonus
   - Dominate Simple Greedy Agent (SGA)
   - Peer competition
   - Beat Hidden Benchmark

Beat the Baselines

- One round consists of 2 games with alternating first player.
- We will calculate the total net score of 5 rounds between your agent and the baseline agents
- You can get $S, S \in \{-2, -1, 0, 1, 2\}$ score for each round
  - Win: $+1$ point
  - Draw: 0 point
  - Lose: -1 point
- We consider total net score no less than zero as beating the baseline.

Bonus

Dominate SGA

- Get total net score of **strictly more than 2** when playing againts Simple Greedy Agent (SGA) in 5 rounds (+1 point)

Peer Competition

- $N =$ number of HW participants.
- We will host a 5-round game between each participant.
- Get net score **strictly more than** $5 \times (N - 1)$ (+1 point).
- Top K agents will be awarded more points, where K will be decided later, based on the results.

Bonus

Beat Hidden Benchmark

- You will have 3 rounds to fight the hidden benchmark.
- $W =$ net score after 3 rounds
- Additional bonus points of $\min(\max(W, 0), 3)$