Exploring and exploiting Monte-Carlo Othello

Richard Deurwaarder

Abstract

The abstract should be one paragraph, indented 1/8 inch on both sides, in 9 point font with single spacing. The heading **Abstract** should be 10 point, bold, centered, with one line space below it. This one-paragraph abstract section is required only for standard spoken papers and standard posters (i.e., those presentations that will be represented by six page papers in the Proceedings). n

Introduction

Monte Carlo planning has long been a good solution to find near optimal solutions to large state space Markovian Decision Problems. This is a type of problem where an action needs to be taken to stochastically move to a new state which will give some kind of reward, this reward needs to be optimized. When the problems become sufficiently large it quickly becomes infeasible to search the whole space and trade-offs need to be made. In this paper I will look at the board game Othello in particular.

Because of the large state space it is useful to gather information about which actions are more promising than other, and put more effort into investigating states which are a result of those actions. This is the classic exploration versus exploitation problem: How much effort do we put into exploring how promising the actions are and how much effort is put into exploiting these actions. One algorithm proposed by Kocsis and Szepesvari[1] called UCT deals with this problem.

UCT has a parameter called the exploration parameter. This determines how likely or unlikely the algorithm is to explore or exploit. In practice this parameter is chosen without too much consideration. In this paper I will try to show the significance of this parameter for the game Othello.

Othello

Othello is a strategy board game for two players. Sometimes also referred to as Reversi. Players are assigned a color and take turns placing pieces on the board while capturing pieces of the other player. The player with most pieces left at the end of the game wins.

Board and moves   Othello is played on a 8x8 uncheckered board. It always has the same starting position, see figure: 1a. Making a move is done by placing a piece on an empty square and capturing at least one piece of the opponent in the process. A piece is captured when it becomes surrounded by the other color, see figure: 1b. When white places a piece on F3. Five pieces get captured and turn white. However E5 does not get captured because it does not get surrounded by F3, it only gets surrounded via the effects of F3.
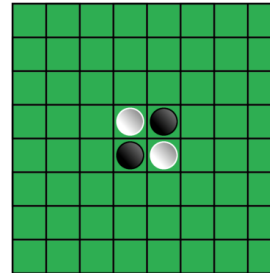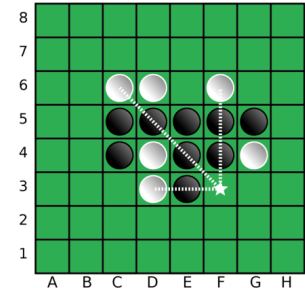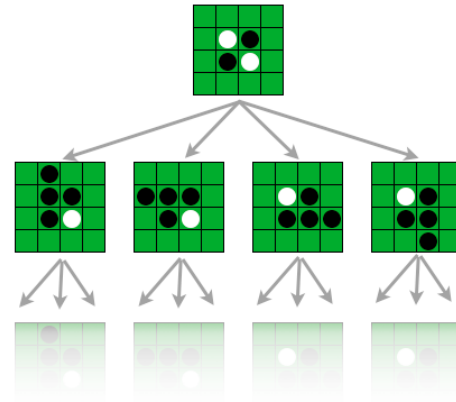
Figure 1: Uncheckered 8x8 boards

Figure 2: Othello tree representation

Importance of different squares   The pieces in the middle of the board might be captured and recaptured multiple times, because they are surrounded by so many different positions but note the corner squares will never be captured once initially filled, because they cannot be surrounded, making it a safe and valuable position to take.

Game results   The winner of the game is determined by the player with the most pieces at the end of the game. The game ends is when no other available moves are left, this might happen before all the squares are filled, because you may only place a piece if you capture at least one other. It does not matter by how many pieces you you beat the opponent.

Monte Carlo Tree search

Tree search   Tree search comes down to searching through tree structures. A game of Othello can be viewed as a tree where each node represents the state of the board with all its pieces and each edge being a valid action that can be taken to
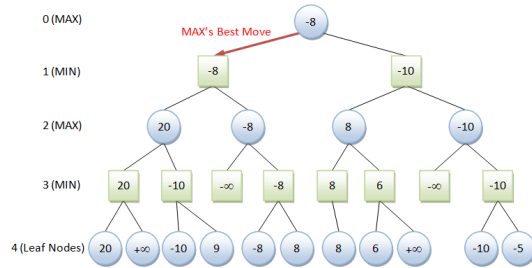
Figure 3: Minimax gametree

transition from one node to the other. See figure 2.

Algorithm 1 Monte Carlo Tree Search
---
function MONTECARLOPLANNING(rootNode)
    while no timeout **do**
        $leafNode \leftarrow$ SELECT($rootNode$)
        ($action, newNode$) $\leftarrow$ EXPAND($leafNode$)
        $reward \leftarrow$ SIMULATE($newNode$)
        $ancestors \leftarrow$ GETANCESTORS($newNode$)
        return UPDATEVALUE(ancestors)
    end while
    return BESTACTION(state, 0)
end function

Monte Carlo Tree Search   A lot of problems' state space is too large to be able to search through the whole tree (as is the case with Othello). One approach that works well is to stop generating more of the tree at some point and do a simulation step. This simulation step will very quickly in usually a stochastic manner finish the game, for instance by making random moves until one of the players has won. The evaluation of this simulation will be the value for the node where the simulation started. This is the basic idea behind Monte Carlo Tree Search (MCTS).

MCTS can be split up in four parts:

1. Select, in this step a node will be chosen uniformly.

2. Expand, in this step an action from the selected node will be taken and a new node or state will be generated.

3. Simulate, in this step a (fast) simulation will take place. For example by taking random actions until the game is over. Note that states generated in the simulation will not be stored or added to the tree. We're only interested in the final evaluation.

4. UpdateValue, After the simulation each relevant node is updated.

Minimax   When MCTS is used to find moves for Othello we cannot ignore the opponent. One approach is to assume the opponent will always make the best possible moves and

we incorporate this behavior in the update value step. In Othello each player will take turns making exactly one move per turn[1]. In the game tree nodes at the same depth

UCT   Aanpassing op UCB1

Algorithm   High level uitleg van het algo en idee er achter. Uitleg per 4 secties.

Parameters   Is deze nodig?

Parallel   3 verschillende manieren van MCTS parallel, en de keuze die ik gemaakt heb en waarom.

Domain knowledge in simulation   Uitleg hoe je domain knowledge in de simulation stage toevoegd. En welke ik heb toegevoegd.

Exploration vs. Exploitation

Uitleg over het 'traditionele' E vs E probleem.

General Formatting Instructions

For standard spoken papers and standard posters, the entire contribution (including figures, references, everything) can be no longer than six pages. For abstract posters, the entire contribution can be no longer than one page. For symposia, the entire contribution can be no longer than two pages.

The text of the paper should be formatted in two columns with an overall width of 7 inches (17.8 cm) and length of 9.25 inches (23.5 cm), with 0.25 inches between the columns. Leave two line spaces between the last author listed and the text of the paper. The left margin should be 0.75 inches and the top margin should be 1 inch. **The right and bottom margins will depend on whether you use U.S. letter or A4 paper, so you must be sure to measure the width of the printed text.** Use 10 point Times Roman with 12 point vertical spacing, unless otherwise specified.

The title should be in 14 point, bold, and centered. The title should be formatted with initial caps (the first letter of content words capitalized and the rest lower case). Each author's name should appear on a separate line, 11 point bold, and centered, with the author's email address in parentheses. Under each author's name list the author's affiliation and postal address in ordinary 10 point type.

Indent the first line of each paragraph by 1/8 inch (except for the first paragraph of a new section). Do not add extra vertical space between paragraphs.

First-Level Headings

First level headings should be in 12 point, initial caps, bold and centered. Leave one line space above the heading and 1/4 line space below the heading.

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[1]It is possible for a player to skip it's turn when the player has no valid move, implementations could fake this skip by creating an action which places no pieces on the board and is only available when no other actions are available

Second-Level Headings

Second level headings should be 11 point, initial caps, bold, and flush left. Leave one line space above the heading and 1/4 line space below the heading.

Third-Level Headings Third-level headings should be 10 point, initial caps, bold, and flush left. Leave one line space above the heading, but no space after the heading.

Formalities, Footnotes, and Floats

Use standard APA citation format. Citations within the text should include the author's last name and year. If the authors' names are included in the sentence, place only the year in parentheses, as in , but otherwise place the entire reference in parentheses with the authors and year separated by a comma . List multiple references alphabetically and separate them by semicolons . Use the et al. construction only after listing all the authors to a publication in an earlier reference and for citations with four or more authors.

Footnotes

Indicate footnotes with a number[2] in the text. Place the footnotes in 9 point type at the bottom of the page on which they appear. Precede the footnote with a horizontal rule.[3]

Tables

Number tables consecutively; place the table number and title (in 10 point) above the table with one line space above the caption and one line space below it, as in Table **??**. You may float tables to the top or bottom of a column, set wide tables across both columns.

Table 1: Sample table title.

Error type	Example
Take smaller	63 - 44 = 21
Always borrow	96 - 42 = 34
0 - N = N	70 - 47 = 37
0 - N = 0	70 - 47 = 30

Figures

All artwork must be very dark for purposes of reproduction and should not be hand drawn. Number figures sequentially, placing the figure number and caption, in 10 point, after the figure with one line space above the caption and one line space below it, as in Figure **??**. If necessary, leave extra white space at the bottom of the page to avoid splitting the figure and figure caption. You may float figures to the top or bottom of a column, or set wide figures across both columns.

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[2]Sample of the first footnote.
[3]Sample of the second footnote.

CoGNiTiVe ScIeNcE

Figure 4: This is a figure.

Acknowledgments

References Instructions

[1] Follow the APA Publication Manual for citation format, both within the text and in the reference list, with the following exceptions: (a) do not cite the page numbers of any book, including chapters in edited volumes; (b) use the same format for unpublished references as for published ones. Alphabetize references by the surnames of the authors, with single author entries preceding multiple author entries. Order references by the same authors by the year of publication, with the earliest first.

Use a first level section heading for the reference list. Use a hanging indent style, with the first line of the reference flush against the left margin and subsequent lines indented by 1/8 inch. Below are example references for a conference paper, book chapter, journal article, technical report, dissertation, book, and edited volume, respectively.

References

[1] Levente Kocsis and Csaba Szepesvari. "Bandit Based Monte-carlo Planning". In: *Proceedings of the 17th European Conference on Machine Learning*. ECML'06. Berlin, Germany: Springer-Verlag, 2006, pp. 282–293. ISBN: 3-540-45375-X, 978-3-540-45375-8. DOI: 10.1007/11871842_29. URL: http://dx.doi.org/10.1007/11871842_29.