Monte Carlo Tree Search on Connect-4

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from math import sqrt, log
from random import choice


class ConnectFour:
    def __init__(self):
        self.player1 = 'x'
        self.player2 = 'o'
        self.height = 6
        self.width = 7
        self.connectNumber = 4
        self.win = 1
        self.lose = -1
        self.tie = 0


    def resultingState(self, state, action, player):
        returnState = []
        for i, col in enumerate(state):
            if i == action:
                returnState.append(col + (player,))
            else:
                returnState.append(col)
        return tuple(returnState)

    def isTerminalState(self, state):
        if all([len(col) == self.height for col in state]):
            return True
        if self.gameOutcome(state, self.player1) == self.win or
self.gameOutcome(state, self.player1) == self.lose:
            return True
        return False

    def actions(self, state):
        possibleActions = [i for i in range(self.width) if len(state[i]) <
self.height]
        return tuple(possibleActions)

    def nextPlayer(self, player):
        if self.player1 == player:
            return self.player2
        return self.player1

    def streakHandler(self, playerToCompare, p1_count, p2_count):
        if playerToCompare == self.player1:
            p2_count = 0
            p1_count += 1
        else:
            p1_count = 0
            p2_count += 1
        return p1_count, p2_count

    def isGameOverUpDown(self, state):
        for colIdx in range(self.width):
            p1_count, p2_count = 0, 0
            for i in range(self.height):
                try:
                    playerAtCurPos = state[colIdx][i]
                except IndexError:
                    break
                p1_count, p2_count = self.streakHandler(playerAtCurPos,
p1_count, p2_count)
                if p1_count == self.connectNumber:
                    return True, self.player1
                if p2_count == self.connectNumber:
                    return True, self.player2
        return False, None  # no winner found


    def isGameOverLeftRight(self, state):
        for rowIdx in range(self.height):
            p1_count, p2_count = 0, 0
            for i in range(self.width):
                try:
                    valueAtCurPos = state[i][rowIdx]
                except IndexError:
                    p1_count, p2_count = 0, 0
                    continue
                p1_count, p2_count = self.streakHandler(valueAtCurPos,
p1_count, p2_count)
                if p1_count == self.connectNumber:
                    return True, self.player1
                if p2_count == self.connectNumber:
                    return True, self.player2
        return False, None


    def isGameOverDiag(self, state):

        for col in range(7):
            for row in range(6):
                try:
                    temp = state[col][row]
                    temp = state[col + 1][row - 1]
                    temp = state[col + 2][row - 2]
                    temp = state[col + 3][row - 3]
                except IndexError:
                    continue
                if row - 3 < 0:
                    continue
                if state[col][row] == state[col + 1][row - 1] == state[col
+ 2][row - 2] == \
                        state[col + 3][row - 3] == self.player1:
                    return True, self.player1
                if state[col][row] == state[col + 1][row - 1] == state[col
+ 2][row - 2] == \
                        state[col + 3][row - 3] == self.player2:
                    return True, self.player2

        for col in range(7):
            for row in range(6):
                try:
                    temp = state[col][row]
                    temp = state[col + 1][row + 1]
                    temp = state[col + 2][row + 2]
                    temp = state[col + 3][row + 3]
                except IndexError:
                    continue
                if state[col][row] == state[col + 1][row + 1] == state[col
+ 2][row + 2] == \
                        state[col + 3][row + 3] == self.player1:
                    return True, self.player1
                if state[col][row] == state[col + 1][row + 1] == state[col
+ 2][row + 2] == \
                        state[col + 3][row + 3] == self.player2:
                    return True, self.player2
        return False, None

    def isGameOver(self, state):
        upDown = self.isGameOverUpDown(state)
        upDownBool, upDownPlayer = upDown[0], upDown[1]
        leftRight = self.isGameOverLeftRight(state)
        leftRightBool, leftRightPlayer = leftRight[0], leftRight[1]
        diag = self.isGameOverDiag(state)
        diagBool, diagPlayer = diag[0], diag[1]

        if upDownBool:
            return upDownPlayer
        if leftRightBool:
            return leftRightPlayer
        if diagBool:
            return diagPlayer
        return None


    def gameOutcome(self, state, player):
        gameOver = self.isGameOver(state)
        if gameOver == player:
            return self.win
        if gameOver is not None:
            return self.lose
        return self.tie


class Node(ConnectFour):
    def __init__(self, daddyNode, action, state, player, game=None):
        super().__init__()
        self.game = game
        self.parentNode = daddyNode
        self.childNodes = dict.fromkeys(self.actions(state))  # creates
dict keys that are made of actions.
        self.action = action
        self.state = state
        self.player = player
        self.visits = 0
        self.value = 0.0

    def nodeWeightForVisits(self):
        return self.value / self.visits if self.visits > 0 else 0


    def mctsWeightFormula(self, c):
        return self.nodeWeightForVisits() + c * sqrt(2 *
log(self.parentNode.visits) / self.visits)


    def allChildrenExpanded(self):
        return None not in self.childNodes.values()


    def expandNode(self):
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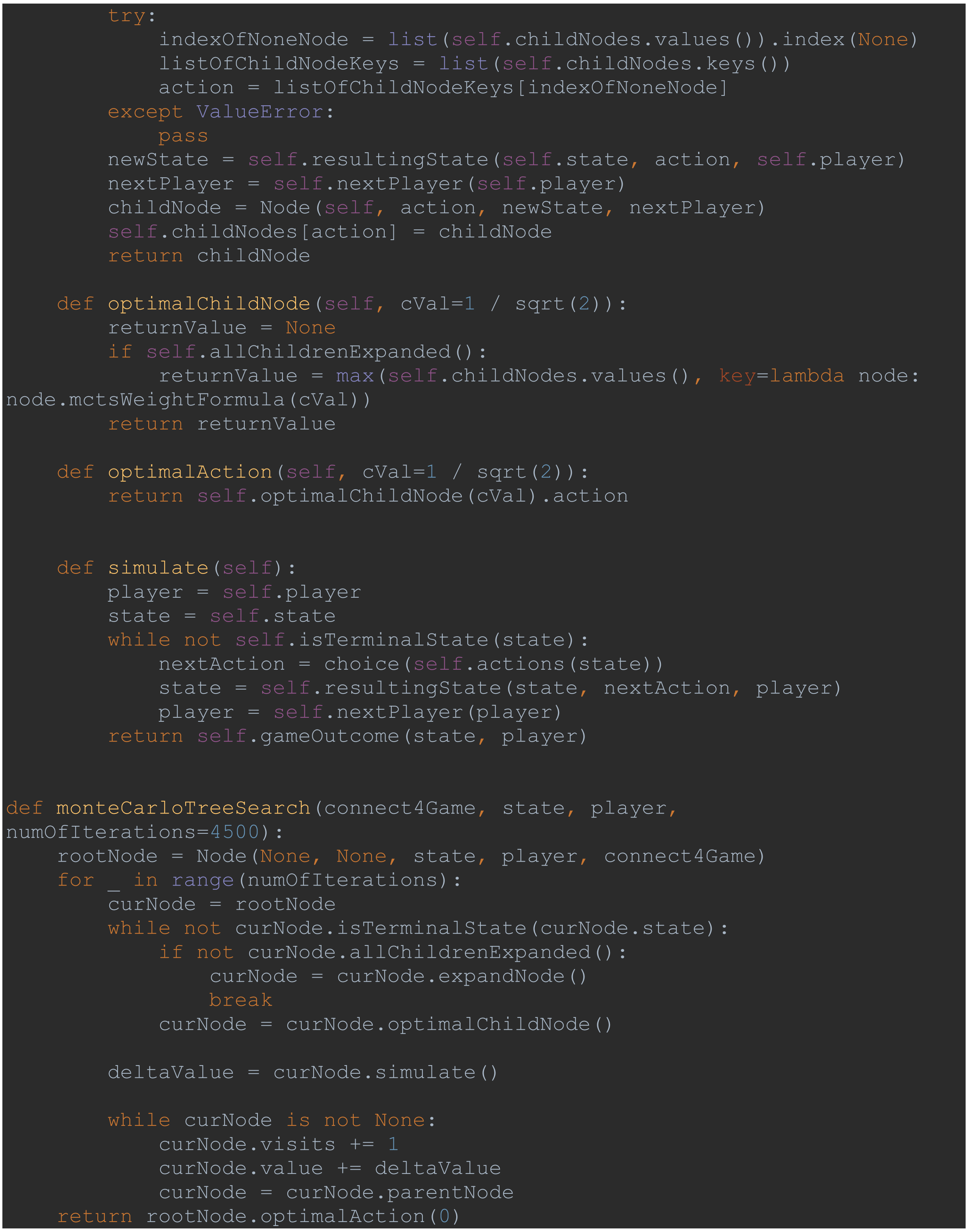

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        try:
            indexOfNoneNode = list(self.childNodes.values()).index(None)
            listOfChildNodeKeys = list(self.childNodes.keys())
            action = listOfChildNodeKeys[indexOfNoneNode]
        except ValueError:
            pass
        newState = self.resultingState(self.state, action, self.player)
        nextPlayer = self.nextPlayer(self.player)
        childNode = Node(self, action, newState, nextPlayer)
        self.childNodes[action] = childNode
        return childNode

    def optimalChildNode(self, cVal=1 / sqrt(2)):
        returnValue = None
        if self.allChildrenExpanded():
            returnValue = max(self.childNodes.values(), key=lambda node:
node.mctsWeightFormula(cVal))
        return returnValue

    def optimalAction(self, cVal=1 / sqrt(2)):
        return self.optimalChildNode(cVal).action


    def simulate(self):
        player = self.player
        state = self.state
        while not self.isTerminalState(state):
            nextAction = choice(self.actions(state))
            state = self.resultingState(state, nextAction, player)
            player = self.nextPlayer(player)
        return self.gameOutcome(state, player)


def monteCarloTreeSearch(connect4Game, state, player,
numOfIterations=4500):
    rootNode = Node(None, None, state, player, connect4Game)
    for _ in range(numOfIterations):
        curNode = rootNode
        while not curNode.isTerminalState(curNode.state):
            if not curNode.allChildrenExpanded():
                curNode = curNode.expandNode()
                break
            curNode = curNode.optimalChildNode()

        deltaValue = curNode.simulate()

        while curNode is not None:
            curNode.visits += 1
            curNode.value += deltaValue
            curNode = curNode.parentNode
    return rootNode.optimalAction(0)
```