Nim, nim.py and games.py

Homework 4

Problem 4

The History of Nim Games

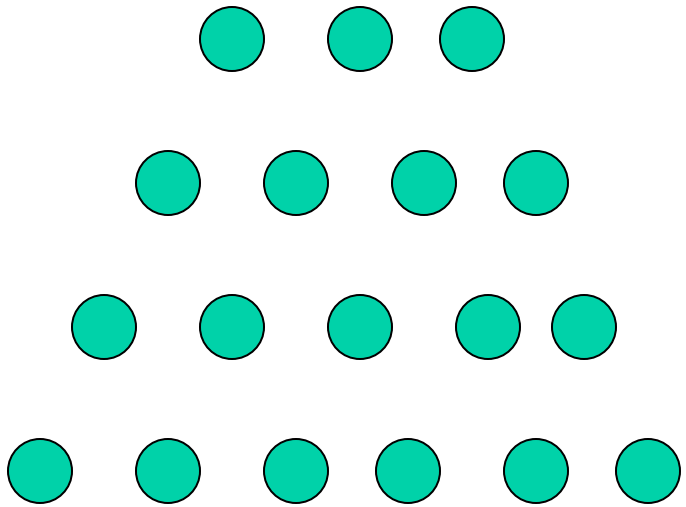
- Believed to have been created in China; unknown date of origin
- First actual recorded date- 15th century Europe
- Originally known as Tsyanshidzi meaning "picking stones game"
- Presently comes from German word "nimm" meaning "take"

Adapted from a presentation by
Tim Larson and Danny Livarchik

Rules of Nim

- Impartial game of mathematical strategy
- Strictly two players
- Alternate turns removing any number of items from any ONE heap until no pieces remain
- Must remove at least one item per turn
- Last player to be able to remove a wins
- Variations:
  - Initial number of heaps and items in each
  - Misere play: last player who can move loses
  - Limit on number of items that can be removed

Demonstration



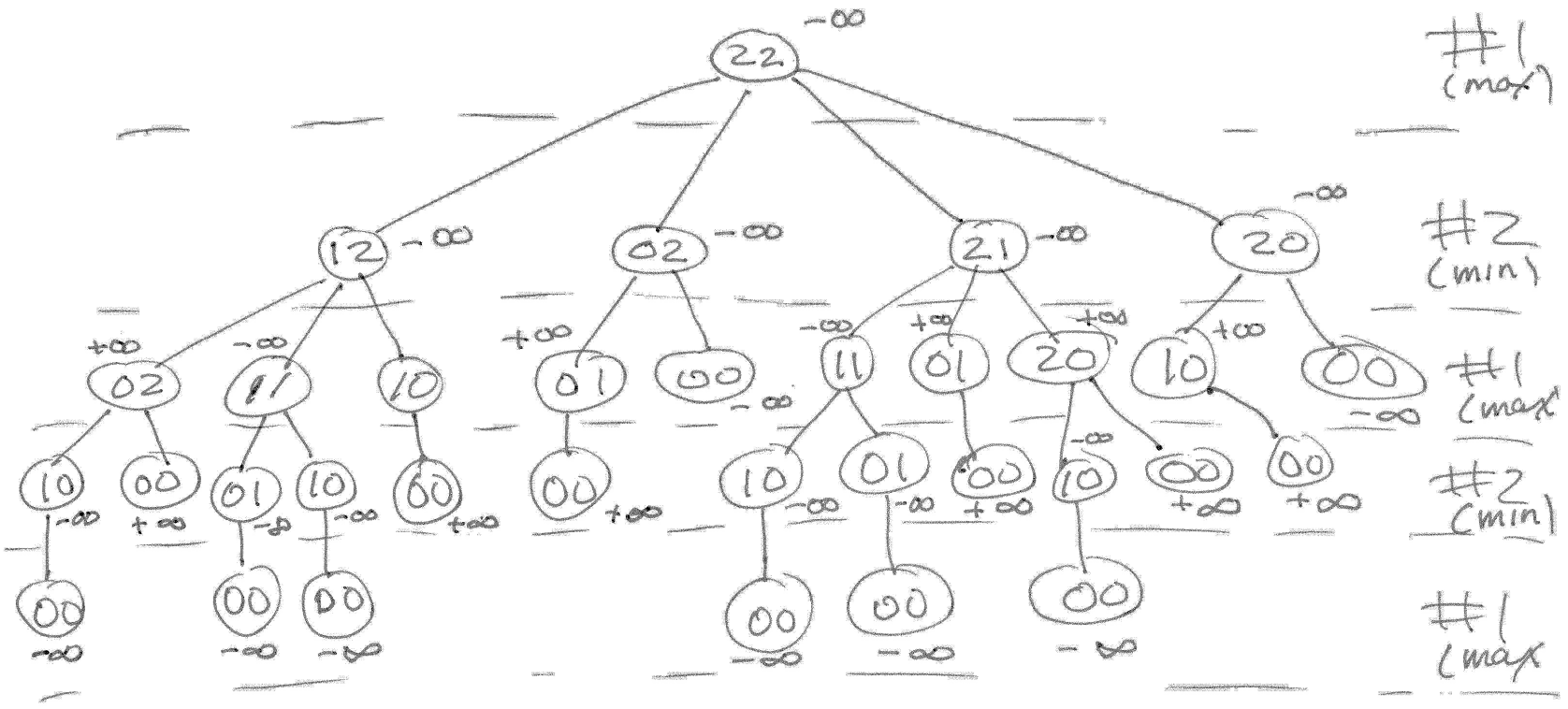
Player 1 wins!

Theoretical Approach

- Theorem developed by Charles Bouton in 1901
- This states that in order to win, the goal is to reach a nim-sum of 0 after each turn until all turns are finished
- Nim Sum: evaluated by taking the exclusive-or of the corresponding numbers when the numbers are given in binary form
- Exclusive-or is used for adding two or more numbers in binary and it basically ignores all carries

Tree for (2,1)

Tree for (2,2)



games.py

- Peter Norvig's python framework for multiple-player, turn taking games
- Implements minimax and alphabeta
- For a new game, subclass the Game class
  - Decide how to represent the "board"
  - Decide how to represent a move
  - A state is (minimally) a board and whose turn to move
  - Write methods to (1) initialize game instance, (2) generate legal moves from a state, (3) make a move in state, (4) recognize terminal states (win, lose or draw), (5) compute utility of a state for a player, (5) display a state

Assumptions about states

- games.py assumes that your representation of a state is a object with at least two attributes: to_move and board
- The Struct class defined in utils.py can be used to create such instances
  - s = Struct(foo='a', to_move = 1, board = [[1][2][3]])
  - Access the attributes as s.to-move, etc.

Caution

- Python lists are mutable objects
- If you use a list to represent a board and whant to generate a new board from it, you probably want to copy it fist

```
new_board = board[:]
new_board[3] = new_board[3] - 1
```

Players

The games.py framework defines several players

- random_player: choses a random move from among legal moves
- alphabeta_player: uses alpha_beta to choose best move, optional args specify cutoff depth (default is 8) and some other variations
- human_player: asks user to enter move

Variations

```
def make_alphabeta_player(N):
    """ returns a player function that uses alpha_beta search to depth N """
    return lambda game, state: alphabeta_search(state, game, d=N)

# add to the PLAYER dictionary player function named ab1,ab2,...ab20
# that use alpha_beta search with depth cutoffs between 1 and 20

for i in range(20):
    PLAYER['ab'+str(i)] = make_alphabeta_player(i)
```