

Theory and Practice of Artificial Intelligence • 2023-2024

Semester B

Exercise Sheet 1

Motto: Python, Games and Recursions

Preliminaries:

1. Install IDLE, PythonWin, PyCharm or some other Python environment on your operating system. Place the starting icon on your laptop. If you prefer to work under Linux, you can use the python command line. We will use Python 3.
2. Make sure in the examples that you debug them and check whether they work.

The Game

We will begin our exercises with a game, the famous Nim game. We consider here at first only the 1-heap Nim game. These are the rules of the game:

1. There are two players who alternate in making a move. Given is a single heap of sticks. The heap contains an integer number $n \in \mathbb{N}$ of sticks.
2. When it is the turn of a player, that player takes a number of sticks from the heap, either 1, 2, or 3, but never more than the remaining number of sticks in the heap.
3. After taking these sticks, it is the other player's turn. They, again, can take 1, 2, or 3 sticks (but never more than the remaining number of sticks).
4. Then, the first player plays again, and so on. The game ends when a player leaves no sticks in the heap.
5. The player who takes the last stick or sticks, wins. Or, said otherwise, the player who first cannot make a move, loses.

In this exercise sheet, you will develop a program that will permit playing the game. Centrally, this should permit a human to play against a computer, but, ultimately should support playing any type of player against any type of player (i.e. human-vs-human, human-vs-computer, computer-vs-computer), with any of them being able to play first.

The following diagram explains the structure of the software that we are aiming for:

Game Controller The game controller is the system that runs the game. It checks who are the participating players, checks who plays first, tells players what the current state of the game is (e.g. initial n , or, how many sticks are left after the other player's move) and asks players for their move in that situation. It also stops the game when it has ended (it will never ask a player for a move when none is possible, i.e. when the game has ended) and will state the outcome of the game (who has won or lost, or if it is a draw).

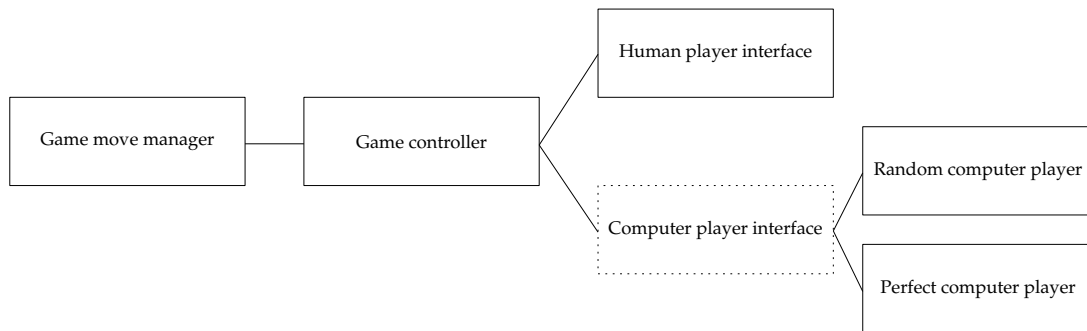


Figure 1: Structure of the Code

Game Move Manager The game controller has access to the game move manager. In the case of Nim, this is just managing how many sticks there are in the heap and how this number changes on sticks being taken away during a move, so it is quite trivial. However, in more complex games, it can be a quite considerable piece of software, and that is why we separate this from the game manager.

Game Controller: Player Selection One role of the game controller is establishing who is playing. Once the players have been selected and the game has begun, from the point of view of the game controller, the players look precisely the same, whether they are human or computer players. However, before that, the game controller needs to find out who plays first and who second. Each of these could be a human, or one of the available computer players. This way, you have maximum flexibility in choosing game combinations. In a well-designed software, this can be flexibly chosen in any manner possible.

Players Once the players are selected, from the point of view of the game controller, the players look *precisely the same*. They get the current situation (*state*) of the game, and return their move. The game controller then alternately selects the player whose turn it is (no matter whether human or computer) to get their move in the given situation.

The player interface looks the same for all players: it takes a game state (in our case, completely defined by the number n of sticks in the heap) and returns a move. A move can specify what a player is doing (*action*) or what the new state is after the player has taken the action (*successor state*). There are advantages in both concepts. For the purpose of the exercises, we will adopt the *action* model, i.e. the players return the action they take, i.e. how many sticks they remove from the heap. In the lecture, we will later encounter the *successor state* concept.

Computer Players As computer player, the simplest player should be one that just returns any fixed or random legal move. Once you have mastered that, you will proceed to an optimal player; you will have to research how to model such a player. There is a simple optimal strategy for a one-heap Nim game.

The interface of the player is simply a Python function that takes the current state (i.e. number of sticks) as argument and returns a move (i.e. an action, as mentioned above, that is, the number of sticks taken at the current stage).

Human Players In the case of the human player, the interface should look precisely the same as for the computer player, a function that takes the current state as argument and returns the move. Inside the function, however, the program queries the human (via some input/output, e.g. a `print` operation) what they want to do in the given situation.

In the following, we will implement these different components, beginning with the computer player.

Assignment 1.1

Write a Python function, implementing a computer player for the 1-heap NIM game.

Rule: Consider a heap of n pieces. Players take alternating turns to remove 1-3 pieces. Whoever manages to take the last piece, wins.

In detail: write a function `nim(n)` that produces a legal move, i.e. it gets `n` as argument, the number of sticks still present on the heap, and returns how many sticks are removed in the current step (which needs to be a legal number of sticks).

You can assume that there is at least one stick, i.e. $n > 0$. This will be later ensured by the game controller.

Hint: You can use a random legal move. In this case, have a look at Python's `random` module.

Once you have completed this, you can extend the problem as follows:

1. improve `nim(n)` to `nim_best(n)` that plays optimally. You will have to research (or discuss in the practical) what the optimal move is.
2. Write a function `nim_human(n)` which asks a human (on command line or input widget) to submit a legal move and returns it.
3. Write a function that permits the human to select two players and returns them in a list — this will be used by the game controller.
4. Write a game controller that runs a game, i.e.
 - it asks the human to select a heap size;
 - it asks the human who should play and lets them select two players;
 - permits the two players (computer or human) to play against each other, printing the progress of the game

Assignment 1.2

You have four numbers (integers or floats) `x,y,z,u`.

Write a function `sort4(.)` that takes 4 numerical arguments and returns a sorted `tuple` of these arguments. Do not use the `list`'s `sort()` method.

Assignment 1.3

Test your sorting algorithm with the permutation generator from the lecture.

Assignment 1.4*

Extend the Tower of Hanoi program to four pins.