Evolutionary Algorithms Winter 2017/2018
PD Dr.-Ing. habil. Christian Borgelt from 2018.01.18

Exercise Sheet 6

Exercise 21 Iterated Prisoner's Dilemma

The lecture discussed the iterated prisoner's dilemma, for which it was tried to find a good strategy using a genetic algorithm. The used payoff matrix is stated again on the right. Here C stands for "cooperate", D for "defect". The fields of the matrix contain the payoffs for the two players A and B.

A\B	C	D
C	3\3	0\5
D	5\0	1\1

In order to better understand the properties of different possible game strategies, we consider in this and the next exercise a few special, simple strategies and try to determine their advantages and disadvantages. We start by considering two players that choose their action randomly, for example, by throwing a coin. Compute the expected payoff for a player and the variance/standard deviation of this payoff!

Exercise 22 Iterated Prisoner's Dilemma

Other simple strategies for the iterated prisoner's dilemma are:

(i) Always play "defect".

(ii) Always play "cooperate".

(iii) Play "Tit-for-Tat", that is, in the first match play "cooperate", in all remaining matches play the move the opponent made in the preceding match.

Consider a tournament in which the three strategies play against each other, in a round robin fashion, a 100-fold iterated prisoner's dilemma (that is, each of the strategies plays 100 matches of the prisoner's dilemma against every other strategy). Which average payoff is achieved by the strategies? What changes if two or three players in the tournament play "Tit-for-Tat" (so that there are, in total, four or five player, respectively)? In these extended cases: what effect do additional players have that always play "defect"?

Additional questions:

a) Up to now we always tried to optimize, with the help of an evolutionary algorithm, the parameters of a function that was defined independently of the evolutionary algorithm. Is there, for the prisoner's dilemma, also an independent function that is optimized? Justify your answer!

b) If not (only) an external function, what is actually optimized if we use an evolutionary algorithm to search for (good) strategies to play the prisoner's dilemma?

Exercise 23 Blackjack

Blackjack (in German also known as "17 and 4") is a card game, that is played by a dealer and a player.[1] The game strategy of the dealer is fixed by the rules of the game. Only the player can make decisions. The objective of the player is to get a hand of cards, the value of which does not exceed 21 and is closer to 21 than the value of the hand of the dealer. The individual cards have the following values: Ace — 1 or 11, picture cards — 10, number cards 2 to 10 — the number stated on them. The suits (clubs, spades, hearts, diamonds) are irrelevant. The value of a hand is the sum of the values of the individual cards contained in it. The ace has a value of 1 or 11, whichever brings the value of the hand closer to 21 without exceeding 21.

At the beginning of the game the player makes a bet. Then the dealer deals two cards each to the player and to him-/herself. In this exercise we consider the variant in which the cards are placed laid out openly for everyone to see (so called "shoe game"). The player now can decide whether he wants to receive more cards. If another card pushes the value of his/her hand beyond 21, he/she loses the game and the bet. However, if with a value of his/her hand of 21 or less he/she does not ask for another card, the dealer completes his/her hand according to fixed rules: The dealer has to take another card as long as the value of his/her hand is below 17 and must not take another card as soon as the value of his/her hand reaches or exceeds 17 (hence the German name "17 and 4"). In order to determine the value of his/her hand, he/she must count an ace as 11, if this is possible without the value of the hand exceeding 21. If the value of the hand of the dealer exceeds 21 or the value of the hand of the player is closer to 21 than the value of the hand of the dealer, the player wins and receives twice his bet. Otherwise the player loses his/her bet.[2]

How can one find a good game strategy for blackjack with the help of an evolutionary algorithm?

Exercise 24 Genetic Programming: Crossover

Design an algorithm that constructs from two given parent programs (for example, in the form of parse trees or Lisp/Scheme expressions) a child program using crossover! In case you know these languages, state the algorithm in Lisp/Scheme.
(Hint: Split the problem into two subproblems:

a) The random selection of an expression and

b) the insertion of an expression at a randomly chosen position (replacing the expression at this position).

How can this function (or a part of it) be used at the same time to implement a mutation operation?

[1] In casinos the game is also played with multiple players at the same time, but moves only concern the dealer and one player, so that we can confine our considerations to one player.

[2] We disregard here certain subleties that are to be considered when playing in a casino, for example, a 50% increase of the winnings if the game is won with a blackjack (exactly 21 with thw first two cards) as well as the split of two equal cards (differing only in their suits) etc.

Additional Exercise Newcomb's Paradox

Newcomb's Paradox (named after its inventor, the physicist William Newcomb) has a structure that is closely related to the prisoner's dilemma. Some creature, which we will call the "prophet", shows two closed boxes, A and B, to you. You can choose whether you want to (1) open only box B or (2) open both boxes. You may keep the content of the boxes you choose to open. The prophet, who claims that he can predict the actions of humans, filled the boxes as follows: Box A always contains 1000 Euro (independent of the prophet's prediction). If the prophet predicted that you will open only box B, the prophet placed one million Euro into box B. However, if the prophet predicted that you will open both boxes, box B is left empty. Furthermore, it is known that many times in the past the prophet predicted the behavior of humans in this situation and was never wrong. What do you do?