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MATH. - NATURWISS. FAKULTÄT
FACHBEREICH INFORMATIK
KOGNITIVE SYSTEME · PROF. A. ZELL

Artificial Intelligence

Assignment 5

Assignment due by: 29.11.2017, Discussion: 1.12.2017

Question 1 Newton's method (7 points)

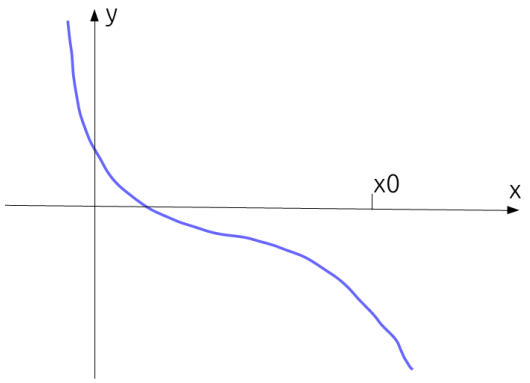


figure a

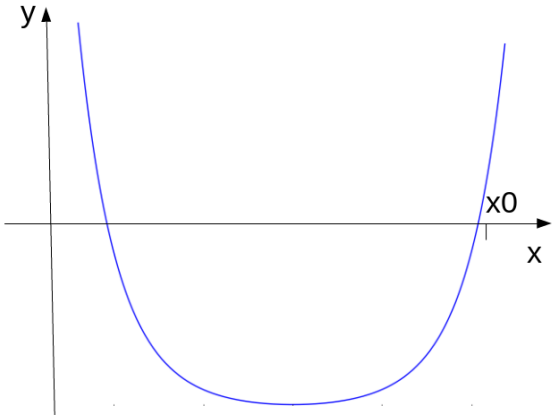


figure b

(a) Using the function displayed in the left figure, and without computation, draw the details of the first three steps of the Newton's method to find the root of the function. (1 point)

(b) Using the function displayed in the right figure, and without computation, draw the details of the first three steps of the Newton's method to find the minimum of the function. (2 points)

(c) Draw an example where Newton's method fails to converge to the root of a real valued function $y = f(x)$ with $x \in \mathbb{R}$. (1 point)

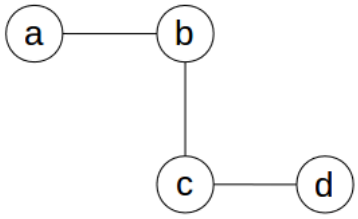
(d) Detail the first two steps of Newton's method when trying to find the minimum of the following function:

$$f(x_1, x_2) = x_1^2 - 2\,x_1^3 + 2\,\exp(x_1) - \exp(-{x_2}^2) - 3 \tag{1}$$

with $(x_1, x_2) \in \mathbb{R}^2$. Use the starting point $(x_1, x_2) = (-1, 0.1)$. For each step specify the gradient (i.e. first-order derivatives, also known as Jacobian), the Hessian (i.e. second-order derivatives) and the inverse of the Hessian of the function. What is the global minimum of this function? Is the Newton's method proposed converging to this minimum? If not, provide a starting point which allows to converge to the global minimum. (3 points)
Hint: Hessian matrix coefficients $\mathbf{H}_{i,j} = \frac{\partial^2 f}{\partial x_i\, \partial x_j}$

Question 2 Searching with no observations (3+2+1 = 6 points)

The graph shown below and a sensorless agent are given. The agent truly knows the topology of the graph but not its (the agent's) position. The starting point can be any of the four states shown in the graph. The agent also knows the movements: upwards (U), downwards (D), right (R) and left (L). There are not illegal movements. If the agent cannot move, it remains in the same state.



(a) Draw the belief-state graph that connects all states that the agent can accept, it should include ALL edges. Label the arrows so that it can be seen by which movement the agent moves into other belief state.

(b) Specify the sequence of movements that the agent should follow to get from any starting point to the goal state **c**. Why is it possible to find the path if the agent does not know its real position?

(c) Explain in no more that 4 lines one method to solve sensorless problems in practice.

Question 3 Genetic Algorithms with LISP (4+3 = 7 points)

(a) Implement a genetic algorithm in LISP to solve the eight queens problem (as shown in the lecture slides). You should use the fitness function $f = 28 - \#\text{conflicts}$ (where conflicts are counted as in Chapter 4, Slide 8) and Roulette-Wheel selection for parents (probability of being chosen as a parent $p_i = \frac{f_i}{\sum_j f_j}$). The mutation rate should be $1/8$ for each queen. *Hint:* you can use `(loop for i from 1 to population collect (make new child))` to make the new population, also `(random n)` returns a random integer from 0 to $n-1$.

(b) Try out your algorithm with varying population sizes or try a different fitness function $f_{new} = f^2$ (or even higher exponents) to see what configuration on average gives the answer in the smallest amount of individuals (population size * number of generations). Report and explain your findings.