UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Exam in **INF3490/4490 — Biologically Inspired Computing**
Day of exam: **December 9th, 2015**
Exam hours: **09:00 – 13:00**
This examination paper consists of 7 pages.
Appendices: **1**
Permitted materials: **None**

Make sure that your copy of this examination paper is complete before answering.

The exam text consists of problems 1-35 (multiple choice questions) to be answered on the form that is enclosed in the appendix and problems 36-39 which are answered on the usual sheets (in English or Norwegian). Problems 1-35 have a total weight of 70%, while problems 36-39 have a weight of 30%.

About problem 1-35:
Each problem consists of a topic in the left column and a number of statements each indicated by a capital letter. Problems are answered by marking true statements with a clear cross (X) in the corresponding row and column in the attached form, and leaving false statements unmarked. Each problem has a variable number of true statements, but there is always *at least one* true and false statement for each problem. 0.5 points are given for each marked true statement and for each false statement left unmarked, resulting in a score ranging from 0 to 60.

You can use the right column of the text as a draft. The form in the appendix is the one to be handed in (remember to include your candidate number).

Problem 1

Biologically inspired computation is appropriate for	A	Optimization	
	B	Modelling	
	C	Safety critical systems	
	D	Simulation	

Problem 2

Exhaustive search	A	Not guaranteed to find the optimal solution	
	B	Test all possible solutions, pick the best	
	C	Relevant for continuous problems by using approximation	
	D	Most relevant for large search problems	

Problem 3

Which of the following are discrete optimization problems?	A	Travelling salesman problem	
	B	Robot control	
	C	Chess playing program	
	D	Prediction of stock prices	

Problem 4

Gradient ascent	A	The direction of the move is towards a larger value	
	B	Relevant for discrete optimization	
	C	Is not guaranteed to find the optimal solution	
	D	The ascent continues until the gradient is very small	

Problem 5

Exploration in search is	A	Concerned with improving the current best solution by local search	
	B	Combined with exploitation in evolutionary algorithms	
	C	Often resulting in getting stuck in local optima	
	D	Concerned with global search	

Problem 6

What *controls* the search in simulated annealing?	A	Time	
	B	Temperature	
	C	Initial solution	
	D	Final solution	

Problem 7

Evolutionary algorithm: Initialization	A	Individuals are normally generated randomly	
	B	Is concerned with generating candidate solutions	
	C	Mutation of candidates is normally also taking place during the initialization	
	D	Heuristics for generating candidates can be applied	

Problem 8

Evolutionary algorithm: Variation operators	A	Is a selection operator	
	B	Act on population level	
	C	Act on individual level	
	D	Are crossover and mutation	

Problem 9

Evolutionary algorithm: Recombination	A	Also known as crossover	
	B	Combines elements of two or more genotypes	
	C	Also known as mutation	
	D	Also known as representation	

Problem 10

Evolutionary algorithm: Survivor selection	A	Is often stochastic	
	B	Also known as replacement	
	C	Can be fitness based	
	D	Can be age based	

Problem 11

Evolutionary algorithm: Termination condition	A	Several termination criteria can be combined	
	B	Determines when to compute the fitness for a population	
	C	Is checked in every generation	
	D	Should be avoided to get faster evolution	

Problem 12

Permutation representation	A	Is used for problems where each variable can only appear once	
	B	Bit-flip mutation is applicable	
	C	A mutation operator that swaps at least two values is applicable	
	D	Is used for problems where each variable can appear multiple times	

Problem 13

Tree representation	A	Is used in Genetic Programming	
	B	Mutation results in replacing a randomly chosen subtree by a randomly generated tree	
	C	Not suited for representing computer programs	
	D	Is used in Genetic Algorithms	

Problem 14

Selection pressure	A	Should be high to avoid premature convergence	
	B	The higher pressure, the harder for the fittest solutions to survive	
	C	Fitness-proportionate selection avoids selection pressure	
	D	Rank-based selection can adjust and control the pressure	

Problem 15

Rank based selection	A	Use relative rather than absolute fitness	
	B	Use absolute rather than relative fitness	
	C	Results in less control of the selection pressure than fitness-proportionate selection	
	D	Ranking can be either linear or non-linear	

Problem 16

Multimodality	A	In crowding, offspring competes with their nearest parent	
	B	In fitness sharing, the fitness decreases if there are many candidates in a niche	
	C	The problem has only one locally optimal solution	
	D	Periodic migration is not relevant in the island model	

Problem 17

Simple Genetic Algorithm (GA)	A	Children compete with parents in survival selection	
	B	Both crossover and mutation are applied in each generation	
	C	The whole population is replaced with the resulting offspring	
	D	Uses real-valued representation	

Problem 18

Evolutionary Strategies (ES)	A	(μ,λ): Select survivors among parents and offspring	
	B	$(\mu+\lambda)$: Select survivors among parents and offspring	
	C	$(\mu-\lambda)$: Select survivors among offspring only	
	D	$(\mu:\lambda)$: Select survivors among offspring only	

Problem 19

What is most important to be concerned with in the evolution of repetitive problems?	A	Do multiple runs until a good solution is found	
	B	Execute one run until the solution is good enough	
	C	Get a reasonably good solution every time	
	D	Get a very good result just once	

Problem 20

What are normally the two best measurement units for an evolutionary algorithm?	A	Number of evaluations	
	B	Elapsed time	
	C	CPU time	
	D	Number of generations	

Problem 21

Multiobjective optimisation problems (MOPs)	A	The travelling salesman problem is an example of a MOP	
	B	Concurrent optimisation of n possibly conflicting objectives	
	C	The Pareto front represents the best solutions found	
	D	The Pareto front consists of dominated solutions	

Problem 22

Learning in neural networks	A	Learning takes place in the neurons	
	B	An error is computed on axon outputs in the human brain	
	C	Learning takes place in the connections between neurons	
	D	Weights in a perceptron represent the strengths of synapses	

Problem 23

Supervised learning	A	Desired outputs are not included	
	B	Desired outputs are included	
	C	Error between desired outputs and actual outputs are computed during training	
	D	The multi-layer perceptron is trained by supervised learning	

Problem 24

Artificial neural networks	A	Are trained by adjusting the network size	
	B	Are trained by adjusting weights	
	C	The weights are either all positive or all negative	
	D	The learning rate controls the amount of weight change	

Problem 25

Why use Multi Layer Perceptron instead of a single layer perceptron?	A	Faster learning	
	B	Easier programming	
	C	Can solve more complex problems	
	D	Can learn multiple decision boundaries	

Problem 26

When can the weights be adjusted in a multilayer perceptron?	A	In the forward pass	
	B	In the backward pass	
	C	In both forward and backward pass	
	D	After computing output values of each training vector	

Problem 27

The activation function in a multilayer perceptron	A	Does thresholding to 0 or 1	
	B	Is used to compute the output value of a node	
	C	Is used for initialization of the network	
	D	Makes it possible to train non-linear decision boundaries	

Problem 28

Cartesian Genetic Programming	A	Is more restricted than the general Genetic Programming	
	B	In evolving circuits, the genes determines function and input to each node	
	C	The level back parameter decides the number of columns in the node-array	
	D	The problem of bloat is larger than for the general Genetic Programming	

Problem 29

Swarm intelligence	A	Global behaviour appears as a result of centralized control	
	B	In Particle Swarm Optimization, velocity and position of particles are updated	
	C	Communication through the environment is called stigmergy	
	D	The probability of choosing a new edge in ant colony optimization is proportional with the pheromone level of the edge	

Problem 30

Support vector machines	A	Only data vectors defining the margins are needed to represent the support vectors	
	B	Can only classify linearly separable data	
	C	Map inputs into a higher-dimensional space	
	D	Margins can be increased by using soft margins	

Problem 31

Ensemble learning	A	Multiple classifiers are trained to be slightly different	
	B	Only the best classifier is applied after training	
	C	Training vectors can be assigned weights during training	
	D	All training vectors available should be used for training each classifier	

Problem 32

Principal component analysis	A	Performs mapping to higher dimensions	
	B	Can be applied for feature extraction	
	C	Components represent the directions along with the most variation in the data	
	D	Is a non-linear transformation	

Problem 33

Unsupervised learning	A	Can be used for training with data sets containing only inputs	
	B	No specific error function is used for training	
	C	Self–organizing maps are increasing dimensions in the data	
	D	A multi-layer perceptron can be trained with unsupervised learning	

Problem 34

K–means clustering	A	Need to know the number of clusters in advance	
	B	Need to know which cluster a data point belongs to	
	C	Each cluster center is moved most in the beginning	
	D	The method always results in the global optimal solution	

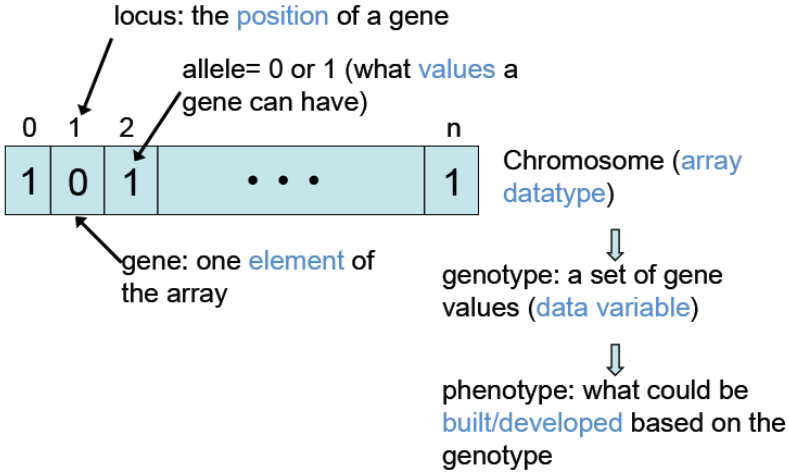
Problem 35

Reinforcement learning	A	The algorithm is told when the answer is wrong, and how to correct it	
	B	Is training using rewards	
	C	A policy defines how actions are chosen	
	D	A discount factor is used to discount future rewards	

Problem 36 (8%)

a) Briefly explain the evolutionary algorithm terms chromosome, gene, locus and allele by including a figure of a chromosome.

b) Explain briefly what a genotype and phenotype are and give an example of each of them.



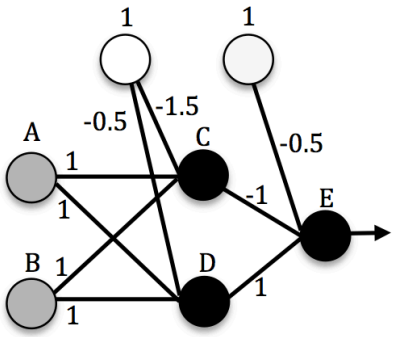
Problem 37 (5%)

In a population of three individuals, they have fitness 2, 3 and 5, respectively. What is the probability for selecting each of them when using a roulette wheel?

Total fitness= 2+3+5= 10, thus, probability for selection is 1/10 for each of the fitness values: 0.2, 0.3 and 0.5.

Problem 38 (9%)

a) Show how the following multi-layer perceptron realizes a XOR-function by computing the output of each node and putting the results into a table:



Each perceptron accepts inputs being 0 or 1 and contains a threshold activation function.

B	A	D (BT)	C (BT)	D (AT)	C (AT)	E (BT)	**E (AT)**
0	0	-0.5	-1.5	0	0	-0.5	**0**
0	1	1-0.5	1-1.5	1	0	1-0.5	**1**
1	0	1-0.5	1-1.5	1	0	1-0.5	**1**
1	1	2-0.5	2-1.5	1	1	1-1-0.5	**0**

BT: Before threshold, AT: After threshold.

b) What values should the weights in the output layer have to make an inverted XOR function (XNOR)? **All output layer weights must be negated (including to the bias). Weight**$_{CE}$= 1, **Weight**$_{DE}$= -1 and **Weight**$_{bias}$= 0.5.

Problem 39 (8%)

List and explain, with one sentence each, up to four of the ethical recommendations for commercial robots the Euronet Roboethics Atelier came up with.

- ***Safety:*** There must be mechanisms (or opportunities for an operator) to control and limit a robot's autonomy.
- ***Security:*** There must be a password or other keys to avoid inappropriate and illegal use of a robot.
- ***Traceability:*** Similarly as aircraft, robots should have a "black box" to record and document their own behavior.
- ***Identifiability:*** Robots should have serial numbers and registration number similar cars.
- ***Privacy policy:*** Software and hardware should be used to encrypt and password protect sensitive data that the robot needs to save.

INF3490/INF4490 Answers problems 1 – 35 for candidate no: _____

Problem	A	B	C	D
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INF3490/INF4490 Answers problems 1 – 35 for candidate no: _____

Problem	A	B	C	D
1	O	O		O
2		O	O	
3	O		O	
4	O		O	O
5		O		O
6		O		
7	O	O		O
8			O	O
9	O	O		
10		O	O	O
11	O		O	
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31	O		O	
32		O	O	
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35		O	O	O