UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Exam in **INF3490/4490 — Biologically Inspired Computing**
Day of exam: **December 4th, 2013**
Exam hours: **14:30 – 18:30**
This examination paper consists of 9 page(s).
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 is answered on the usual sheets. Problems 1-35 have a total weight of 70%, while problems 36-39 have a total weight of 30%.

About problems 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 a clear cross (X) in the right column for the correct answer option (i.e. that a statement is true) in the attached form. There is always *at least one* correct statement for each problem but there is often *more than one* correct statement. To get the best grade, you should mark all the correct statements:

- 1 point is given for each marked correct (true) statement.
- -1 point is given for each marked statement not being true.
- -1 point is given for a correct statement not being marked.

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

Machine learning	A	Represents learning by examples	
	B	Is not very applicable to classification problems	
	C	Biology-inspired methods could be used for machine learning	
	D	Gradient descent is an alternative to machine learning	

Problem 2

Gradient descent	A	Gradient descent will always find the global optimum	
	B	Steps are taken proportional to the gradient of the function at the current point	
	C	The starting point could affect if a global optimum is found	
	D	The descent continues until the gradient is very large	

Problem 3

Search	A	Could also be called discrete optimization	
	B	Exhaustive Search is a time effective search method	
	C	The Traveling Salesman Problem (TSP) is a search problem	
	D	Hill climbing is an effective method for global search in a complex search space	

Problem 4

Exploration and exploitation	A	Search in not concerned with exploration and exploitation	
	B	Exploration is important to find the global best solution	
	C	Exploration and exploitation can not be combined in evolution	
	D	Exploitation consists of trying out local variations of a currently known good solution	

Problem 5

Simulated annealing algorithm	A	The temperature is increased until a solution is found	
	B	Is a stochastic algorithm (based on randomness)	
	C	Can be used for search problems	
	D	Is an alternative algorithm to evolutionary methods	

Problem 6

Evolutionary algorithms	A	Are often deterministic	
	B	Do usually work on a number of solutions at the same time	
	C	Require information about gradients	
	D	Cannot be used for discrete optimization problems	

Problem 7

Evolutionary algorithms: Strategy parameters	A	Can be used with permutation representations	
	B	Can be used with real-valued representations	
	C	Help accurately finding optima	
	D	Are only used in Evolution Strategies	

Problem 8

Evolutionary Programming typically has	A	Deterministic parent selection	
	B	Deterministic survivor selection	
	C	Probabilistic recombination	
	D	Probabilistic mutation	

Problem 9

Permutation representations are compatible with	A	Swap mutation	
	B	Order crossover	
	C	2-point crossover	
	D	Partially mapped crossover	

Problem 10

Tournament selection	A	Requires information about the whole population	
	B	Selection pressure is affected by how far the fitness values are from zero	
	C	Is exclusively used for survivor selection	
	D	Can be applied to multiple objectives easily	

Problem 11

Multi-modality: Basins of attraction	A	Can usually be identified from the problem definition	
	B	Are each associated with one local optimum	
	C	Having at least one individual in each guarantees finding the global optimum	
	D	Are only of importance when creating the initial population	

Problem 12

Multi-objective evolutionary algorithms	A	May be implemented by reducing the objectives to a single scalar objective	
	B	Require a modification of the recombination operator compared to single-objective EAs	
	C	Can use Pareto dominance for comparing solutions	
	D	Will usually have more than one optimal solution	

Problem 13

Hybrid Evolutionary Algorithms	A	Is useful to speed up evolution or improve solution quality	
	B	Memetic algorithms typically improve performance using local search and problem specific information	
	C	Hybridization should only be added to one stage of the algorithm	
	D	In Baldwinian learning, both fitness and genotype are improved	

Problem 14

Particle Swarm Optimization (PSO)	A	Optimizes a population of solutions, called chromosomes	
	B	Velocity and position of each solution are updated	
	C	Similar to evolution, some solutions are selected for survival	
	D	Provides the advantage of decentralized control	

Problem 15

Evolvable hardware (EHW)	A	In EHW, hardware systems are designed/modified automatically by evolutionary algorithms	
	B	FPGAs are useful for online EHW	
	C	Solutions are always first simulated before tested on the physical hardware	
	D	Applicable to both analog and digital hardware	

Problem 16

Supervised learning	A	Is an alternative to machine learning	
	B	Training data includes both inputs and desired outputs	
	C	To achieve generalization, the actual outputs of the system being trained should be as close as possible to the target outputs (training data outputs)	
	D	Multi-layer perceptron is trained with supervised learning	

Problem 17

Classification	A	The goal is to correctly predict for a test data input the corresponding class label.	
	B	Training is often concerned with discrete optimization	
	C	Non-linear decision boundaries often result in better classification compared to using linear boundaries (straight lines).	
	D	Travelling Salesman Problem is a classification benchmark	

Problem 18

Neural Networks	A	Nerve cells in the brain are called neurons	
	B	The output from the neuron is called dendrite	
	C	One kind of neurons is called synapses	
	D	Learning takes place in the synapses	

Problem 19

The perceptron	A	Invented by Hebb	
	B	Is a simplified model of the biological neuron	
	C	Can be used to make multi-layer neural networks	
	D	Weights can be trained by adjusting them by an amount proportional to the difference between the desired output and the actual output	

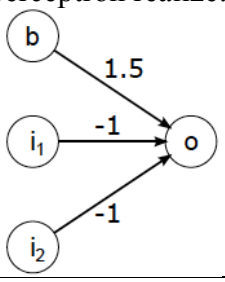
Problem 20

Compute the output of a perceptron with three inputs and weight values 1, 2 and 3 (there is no threshold function). There is also a bias weight of -0.5. The input is (1,1,1).	A	-3	
	B	4.5	
	C	5.5	
	D	6	

Problem 21

What is the output in the previous problem if a threshold function is applied on the perceptron output (threshold value is 0)?	A	−1	
	B	0	
	C	0.5	
	D	1	

Problem 22

Which function do the following perceptron realize: 	A	NAND	
	B	NOR	
	C	AND	
	D	OR	

Problem 23

Multilayer perceptron network	A	Is a neural network with several layers of nodes (or weights)	
	B	There are connections both between and within each layer	
	C	The number of units in each layer must be equal	
	D	Multiple layers of neurons allow for more complex decision boundaries than a single layer	

Problem 24

Backpropagation	A	Is a learning algorithm for multilayer perceptron networks	
	B	The backward pass follows after the forward pass	
	C	Is based on a gradient descent technique to maximize the mean square difference between the desired and actual outputs	
	D	Is also applicable to self-organizing feature maps	

Problem 25

Weight updates in Backpropagation	A	Usually, the weights are initially set to 0	
	B	Are proportional to the difference between the desired and actual outputs	
	C	The weight change is also proportional to the input to the weight layer	
	D	The output layer weights are used for computing the error of the hidden layer	

Problem 26

$f(x) = \frac{1}{1+e^{-x}}$	A	f(x) is called a sigmoid function	
	B	It is beneficial because it does not limit the output value	
	C	It is called an activation function and such a function is used on every multilayer perceptron output	
	D	The derivative of the function is *(f(x) + 1) f(x)*	

Problem 27

Overfitting	A	When the trained system matches the training set perfectly, overfitting may occur	
	B	Indicates limited generalization	
	C	Should be avoided mainly because of the long training time	
	D	Stopping training earlier could reduce the problem	

Problem 28

Support Vector Machines (SVM)	A	Inputs are mapped to lower dimensional space where data becomes likely to be linearly separable	
	B	Is a method useful for classification	
	C	Is very useful since overfitting is never a problem	
	D	Uses kernel functions to do dimensionality mapping	

Problem 29

Ensemble Learning	A	Makes classification based on a combination of classifiers	
	B	Classifiers should be trained to be as similar as possible	
	C	In bagging, each classifier is trained on a random sample of the training data	
	D	Minority voting is used if there is disagreement	

Problem 30

Principal component analysis (PCA)	A	Rotates the axes to lie along the principal components	
	B	Is calculated from the covariance matrix	
	C	Removes some information from the data	
	D	Eigenvectors describe the length of the principal components	

Problem 31

Unsupervised learning	A	Algorithms for supervised learning are not directly applicable for unsupervised learning	
	B	Used when we have no information about the correct output of the training data	
	C	The learning algorithm detects similarity between different training data inputs	
	D	Clustering of inputs is often taking place during learning	

Problem 32

Self-Organizing Feature Map	A	Is an artificial neural network trained using unsupervised learning	
	B	Inputs that are similar excite neurons that are near to each other	
	C	Multiple weight layers are often used for better learning performance	
	D	The network can only perform linear mapping	

Problem 33

Self-Organizing Feature Map (SOFM) learning	A	Each neuron in a SOM is assigned a weight vector with the same dimensionality as the input space	
	B	Inputs are multiplied by all connected weights in the network	
	C	The number of weights being modified for each training vector is reduced throughout learning	
	D	Is called competitive learning since one neuron is chosen as the winner	

Problem 34

Reinforcement learning	A	Learns a behavior that maximizes reward	
	B	Is a kind of neural network	
	C	Is inspired by animal behavior	
	D	Is typically used for continuous optimization problems	

Problem 35

Reinforcement learning: Immediate rewards	A	Must be positive	
	B	Can be used to estimate long-term rewards	
	C	Are problem-defined	
	D	Are stored in the Q table	

Problem 36 (9%)

For each of the three representation types

- Binary
- Integer
- Real-valued

Name or describe one mutation and one crossover operator that is suitable, and briefly describe a problem for each of the types where the representation would be a good choice.

Problem 37 (7%)

One alternative way of training a multi-layer perceptron network would be to use an evolutionary algorithm to evolve all the weights in the network. Describe how you would set up a comparison (that is as fair as possible) between evolving the weights and using the more conventional method of training the network. The algorithms themselves should not be described. You can also assume that the parameters of the algorithms have already been tuned, and that a suitable dataset is available.

Problem 38 (8%)

Briefly describe the different steps in the K-means algorithm. Illustrate an example for K=2 where K-means is not able to classify two classes of data correctly. Explain why.

Problem 39 (6%)

Briefly explain why reinforcement learning uses a discount factor, and how it is applied.

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

Problem	A	B	C	D
1				
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INF3490/INF4490 Correct answers problems 1 – 35

Problem	A	B	C	D
1	O		O	
2		O	O	
3	O		O	
4		O		O
5		O	O	O
6		O		
7		O	O	
8	O			O
9	O	O		O
10				O
11		O		
12	O		O	O
13	O	O		
14		O		O
15	O	O		O
16		O		O
17	O		O	
18	O			O
19		O	O	O
20			O	
21				O
22	O			
23	O			O
24	O	O		
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26	O		O	
27	O	O		O
28		O		O
29	O		O	
30	O	O	O	
31	O	O	O	O
32	O	O		
33	O		O	O
34	O		O	
35		O		