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Engineering, Built Environment and IT
Department of Computer Science

COS 314

Tutorial/Practical 5 Solutions

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Questions

1. Classify the following learning methods as supervised or unsupervised:
   (a) K-nearest neighbour (1)
   Sol: unsupervised
   (b) Support Vector Machine (1)
   Sol: Depends on problem as it can be applied to both
   (c) Decision Tree. (1)
   Sol: unsupervised
   (d) Multi-layer Perceptron (Neural Network). (1)
   Sol: unsupervised

2. Differentiate between the following algorithms.
   (a) Simulated Annealing and a Genetic Algorithm. (2)
   Sol: SA is a single point search(1), it uses a temperature parameter to escape a local optimum through accepting "weaker" solutions. GA is a multipoint search(1)
   (b) Tabu Search and Grammatical Evolution. (2)
   Sol: TS is a single point search(1), it uses a taboo list. It is also able to escape an local optimum through accepting "weaker" solutions. GE is a multipoint search(1)

3. What is the difference between a single layer perceptron and a multi-layer perceptron. (2)
   A single layer perceptron has an input layer and an output layer and can solve linear problems (1). A multilayer has at least one hidden layer and is able to solve non-linear problems (1).

4. What purpose do Loss functions serve in an ANN. (1)
   It evaluates the error between the predicted out and the expected output which can then be used to improve the ANN

5. Given the grammar and the genotype in Figure 1 answer the questions that follow.
   (a) Using the genotype provided derive the associated phenotype. (8)
   Sol: The first step is to convert the genotype (binary codons) to decimal. Then use the rule = (codon decimal value % number of production rules) to process the non-terminal.

1011010	100000	11000	0101	10111	1111010	1011111

<expr> ::= <func><var><op><func><var>
<func> ::= sin | cos | tan
<var> ::= 20^0 |30^0|45^0| 60^0|90^0|180^0
<op> ::= + | - | / | *

Figure 1: Variable Length Individual and Grammar

S = <expr> then replace <expr> with the single rule.
S = <func><var><op><func>< var>
starting with the left most non-terminal 90% 3 = 0 thus rule 0 from the 1st codon (90) of the genotype
S = sin<var><op><func>< var>
32%6 = 2 thus rule 2 (45^o)of var is selected
S = sin 45^o<op><func>< var>
24%4 = 0 rule 0 of op i.e +
S = sin 45^o+<func>< var>
5%3 = 2
S = sin 45^o+ tan< var>
23%6 = 5
S = sin 45^o+ tan 180^o (8marks)

(b) Provide a drawing of the derivation tree. (2)

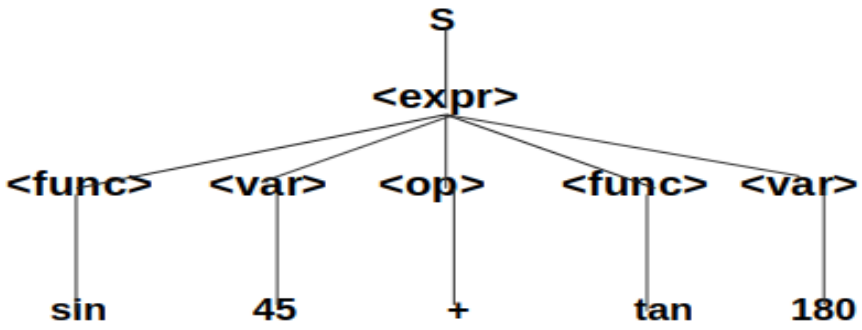

Figure 2: Variable Length Individual and Grammar

6. Which learning tasks are linear units more useful than tanh activation functions in the output layer of a multi-layer neural network? (2)

7. What are optimisers used for in ANNs (2)
Sol: optimisers are used in weight, learning rate and/or momentum adjustment in ANNs e.g backpropagation (2)

8. Distinguish between an *epoch*, *batch* and an *iteration* (3)
Sol: An epoch is when the neural network goes through the complete set of data once i.e one forward and backward pass . A batch is a subset of the dataset. If it is too large it may be split into batches. An iteration is when we have gone through one batch of many

9. Given the following weights (4)
w_1 = 3, w_2 = -1,w_3 = -0.5, w_4 = -3, w_5 = 2.
Given the step function as an activation function
ϕ(y) = 1 if y > 0 else if ϕ(y) = 0 if y $\leqslant$ = 0
Calculate the outputs of a perceptron given the following inputs.

P_1 = [1,0,1,0,1], P_2 = [1,1,1,0,0], P_3 = [0,0,1,1,1], P_4 = [1,0,1,0,1]

Sol weighted sums and evaluate ϕ
for P_1, y = 1*3 + 0*-1 + 1*-0.5 +0*-3 + 1*2 = 4.5 which means ϕ(4.5) = 1, since y > 0
for P_2, y = 1*3 + 1*-1 + 1*-0.5 +0*-3 + 0*2 = 1.5 which means ϕ(1.5) = 1, since y > 0
for P_3, y = 0*3 + 0*-1 + 1*-0.5 +1*-3 + 1*2 = -1.5 which means ϕ(-1.5) = 0, since y < 0
for P_4, y = 1*3 + 0*-1 + 1*-0.5 +0*-3 + 1*2 = 4.5 which means ϕ(4.5) = 1, since y > 0

10. Given the following vectors p_1 = [0 0 1], p_2 = [0 1 0], p_3 = [1 0 0], p_4 = [1 1 0], where p_n = [x_1 x_2 y_o] x_1 and x_2 are inputs and y_o is the output. Use the perceptron rule to evaluate the weights w_1, w_2 and bias b values that will yield the desired outputs. (4)
Sol: The perceptron rule is if *weighted_sum + bias*> 0 then y =1 else y =0.
We firstly initialize the weights and bias randomly since what we are given are the inputs and output to the network so we need to workout the weights and bias values that will satisfy all the given vectors.
Randomly w_1 = 1 , w_2 = 1 and b =-1
Then process vector p_1 : x_1*1 + x_2*1 -1 − > 0(1) +0(1) -1 = -1
The perceptron rule says if the weighted sum + weighted bias ≤ 0 then y = 0
This result is false as the expected is 1 we then need to make adjustments. To get 1 for these inputs we need to set the bias to 1, therefore 0+0+ 1 = 1.
Then for vector p_2 = 0(1) + 1(1) + 1 = 2 *weighted_sum* > 0 thus (y) = 1 which is wrong as the expected is 0.
Again we then need to adjust we set w_2 = -1 since we want a 0 result. This works for both vector p_1 and vector p_2.
We now consider the next vector p_3 = 1(1) + 0(-1) + 1 = 2 *weighted_sum* > 0 thus (y) = 1 which also is wrong as the expected is 0. We change the value of w_2 to -1. This satisfies vectors p_1, p_2 and p_3.
Vector p_4 = 1(-1) + 1(-1) + 1 = -1 *weighted_sum* < 0 thus (y) = 0 is the expected result.
Therefore for the given vectors w_1 = -1 , w_2 = -1 and b =1 satisfies the network
Working out each vector is worth 1 mark

11. Complete the Feature Map extraction by applying the convolution operator on the 2D example in the Lecture slides for CNNs. **Implementational**

12. Using the car dataset found in the UCI repository. Design and implement a multilayer artificial neural network classifier. The ANN must use a genetic algorithm to learn, i.e the GA is used to update the weights of the neural network. **Implementational**

13. Using a library (python) of your choice import the MNIST dataset, split the dataset into a training dataset and testing dataset, configure the neural network and assign values to the hyper-parameters and then run the model to obtain the results. **Implementational**