### *Course: CSC14003 – Introduction to Artificial Intelligence*

### *Class 21CLC – Term II/2022-2023*

Homework 04

***Submission Notices:***

* *Conduct your homework by filling answers into the placeholders in this file (in Microsoft Word format).*

*Questions are shown in black color, instructions/hints are shown in italics and blue color, and your content should use any color that is different from those.*

* *After completing your homework, prepare the file for submission by exporting the Word file (filled with answers) to a PDF file, whose filename follows the following format,*

*<StudentID-1>\_<StudentID-2>\_HW01.pdf (Student IDs are sorted in ascending order)*

*E.g.,* ***2112001\_2112002\_HW02.pdf***

*and then submit the file to Moodle directly WITHOUT any kinds of compression (.zip, .rar, .tar, etc.).*

* *Note that you will get zero credit for any careless mistake, including, but not limited to, the following things.*
  1. *Wrong file/filename format, e.g., not a pdf file, use “-” instead of “\_” for separators, etc.*
  2. *Disorder format of problems and answers*
  3. *Conducted not in English*
  4. *Cheating, i.e., copying other students’ works or letting other students copy your work.*

**Problem 1. (2pts)** Identify each of the following activation functions.

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **2-D representation** | **#** | **2-D representation** |
| a | Các hàm kích hoạt (activation function) trong neural network ... | b | Các hàm kích hoạt (activation function) trong neural network ... |
| c | Các hàm kích hoạt (activation function) trong neural network ... | d |  |
| e |  | f |  |
| g |  | h | Các hàm kích hoạt (activation function) trong neural network ... |

*Please fill your answer in the table below*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | a | b | c | d |
| **Function name** |  |  |  |  |
| **#** | e | f | g | h |
| **Function name** |  |  |  |  |

**Problem 2. (1pt)** Present two objective metrics that can be used to evaluate the attributes for a node on the decision tree. For each metric, you need to present the formula, identify its domain (i.e., range of values), and explain for every term in the formula.

*Please fill your answer in the table below*

|  |  |  |
| --- | --- | --- |
| **Metric name** | **Formula** | **Explanation** |
|  |  |  |
|  |  |  |

**Problem 3. (2pts)** You are given the following tables, which represent the outcomes of some functions. The functions take two values and and output the outcomes of the operations. Please identify **at least two models** for each of the functions that are perfectly represent the functions for some choice of parameters. Justify your answer. Note: there are no constraints on the architecture (e.g, the number of neurons, activation function, or the best splitting criterion), and the depth of decision tree is 0-index.

1. (1pt)

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 0 | 0 | **0** |
| 0 | 1 | **1** |
| 1 | 0 | **1** |
| 1 | 1 | **0** |

* A neural network with no hidden layer
* A neural network with a single hidden layer
* A decision tree of depth one
* A decision tree of depth two

**Explanation:** ...........................

1. (1pt)

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 0 | 0 | **1** |
| 0 | 1 | **0** |
| 1 | 0 | **0** |
| 1 | 1 | **0** |

* A neural network with no hidden layer
* A neural network with a single hidden layer
* A decision tree of depth one
* A decision tree of depth two

**Explanation:** ……………………….

**Problem 4. (2pts)** Consider the following training dataset, in which **Transportation** is the target attribute. Show calculations to choose an attribute for the **root node** of the ID3 decision tree

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Gender** | **Car Ownership** | **Travel Cost** | **Income Level** | **Transportation** |
| Male | 0 | Cheap | Low | Bus |
| Male | 1 | Cheap | Medium | Bus |
| Female | 1 | Cheap | Medium | Train |
| Female | 0 | Cheap | Low | Bus |
| Male | 1 | Cheap | Medium | Bus |
| Male | 0 | Standard | Medium | Train |
| Female | 1 | Standard | Medium | Train |
| Female | 1 | Expensive | High | Car |
| Male | 2 | Expensive | Medium | Car |
| Female | 2 | Expensive | High | Car |

*Please fill your answer in the table below*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Counts | | | Metric values | | |
| Attribute values | Bus | Car | Train | H | AE | IG |
| **Whole** |  |  |  |  |  |  |  |
| Gender (0.5pt) | Female |  |  |  |  |  |  |
| Male |  |  |  |  |
| Car Ownership (0.5pt) | 0 |  |  |  |  |  |  |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| Travel Cost  (0.5pt) | Cheap |  |  |  |  |  |  |
| Expensive |  |  |  |  |
| Standard |  |  |  |  |
| Income Level  (0.5pt) | Low |  |  |  |  |  |  |
| Medium |  |  |  |  |
| High |  |  |  |  |

**Problem 5. (3pts)** Consider the following neuron network, which includes 3 input neurons, 2 hidden neurons and 1 output neurons.

Diagram

Description automatically generated

Initial input, weight and bias values are

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| x1 | x2 | x3 | w14 | w15 | w24 | w25 | w34 | w35 | w46 | w56 | θ4 | θ5 | θ6 |
| 1 | 0 | 1 | 0.2 | –0.3 | 0.4 | 0.1 | –0.5 | 0.2 | –0.3 | –0.2 | –0.4 | 0.2 | 0.1 |

The expected output value is 1. The learning rate is 0.9.

Knowing that the actual output at some neuron *j* is calculated as follows.

where *n* is the number of inputs of neuron *j*, is the corresponding link from a neuron *i* in the previous layer to neuron *j*, and is the bias at neuron *j*.

Present all calculations required to perform the backpropagation once (i.e., one forward pass and one backward pass) on the given neural network in the following cases

1. Ignore all biases *(precision to 3 decimal places).*

*(0.25pt) Ignore all biases – Forward*

|  |  |  |  |
| --- | --- | --- | --- |
| Neuron | 4 | 5 | 6 |
| Output |  |  |  |

*(1pt) Ignore all biases – Backward*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weight | w46 | w56 | w14 | w15 | w24 | w25 | w34 | w35 |
| Value |  |  |  |  |  |  |  |  |

1. Consider all biases such that each bias is treated as a neuron and thus it will be also updated *(precision to 3 decimal places).*

*(0.25pt) Consider all biases – Forward*

|  |  |  |  |
| --- | --- | --- | --- |
| Neuron | 4 | 5 | 6 |
| Output |  |  |  |

*(1.5pt) Consider all biases – Backward*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Weight | w46 | w56 | w14 | w15 | w24 | w25 | w34 | w35 | θ4 | θ5 | θ6 |
| Value |  |  |  |  |  |  |  |  |  |  |  |