TubesA_13519096

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1 Tugas Besar A - IF3270 Pembelajaran Mesin

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1.1 Install Libraries

[ ]:
```
!pip install icecream
!pip install networkx
!pip install pandas
!pip install numpy
!pip install matplotlib
```

1.2 Load libraries

[368]:
```
import pandas as pd
import os, subprocess, sys
import json, math, typing, copy
import numpy as np, networkx as nx, matplotlib as plt
from icecream import ic
```

1.3 Enums

[369]:
```
class LayerType:
        INPUT = "input"
        HIDDEN = "hidden"
        OUTPUT = "output"

class ActivationFunction:
        SIGMOID = "sigmoid"
        RELU = "relu"
        SOFTMAX = "softmax"
        LINEAR = "linear"
```

1.4 Utility Functions

[370]:
```
class Utils:
        @staticmethod
        def matrix_dimension(mat: typing.List[list]) -> typing.Tuple[int, int]:
                return len(mat), len(mat[0])

        @staticmethod
        def get_layer_type(type: str):
                if type == 'input':
                        return LayerType.INPUT
                elif type == 'hidden':
                        return LayerType.HIDDEN
                elif type == 'output':
                        return LayerType.OUTPUT

        @staticmethod
        def get_activation_func(activation_func: str):
                if activation_func == 'sigmoid':
                  return ActivationFunction.SIGMOID
                elif activation_func == 'linear':
                  return ActivationFunction.LINEAR
                elif activation_func == 'relu':
                  return ActivationFunction.RELU
                elif activation_func == 'softmax':
                  return ActivationFunction.SOFTMAX

        @staticmethod
        def parse_json(filename):
                with open(filename, 'r') as f:
                        data = json.load(f)
                        return data

        @staticmethod
        def export_json(filename, data):
                with open(filename, 'w') as f:
                        f.write(json.dumps(data, indent=2))

        @staticmethod
        def install(package):
                subprocess.check_call([sys.executable, "-m", "pip", "install",␣
 ↪''.join(package)])
```

1.5 Layer Class

[371]:
```
class Layer:
        def __init__(self, weights: typing.List[list],
                                bias_weights: typing.List[float],
                                values: typing.List[list],
                                layer_type: LayerType,
                                label: str,
                                num_nodes: int,
                                activation_func: ActivationFunction):
                self.weights = np.array(weights, dtype=float)
                self.bias_weights = np.array(bias_weights, dtype=float)
                self.values = np.array(values, dtype=float)
                self.label = label
                self.type = layer_type
                self.num_nodes = num_nodes
                self.activation_func = activation_func

        def __str__(self):
                if self.type != LayerType.INPUT:
                        res = "{} layer with {} weights".format(self.label,␣
 ↪len(self.weights))
                else:
                        res = "{} layer with {} values".format(self.label,␣
 ↪len(self.values))
                return res
```

1.6 Graph Class

[372]:
```
class Graph:
        def __init__(self, layers: typing.List[Layer]=None):
                self.layers = []
                if layers is not None:
                        self.layers = layers

        def __str__(self):
                return "Graph with {} layers".format(len(self.layers))

        def add_layer(self, layer: Layer):
                self.layers.append(layer)

        def net_value_vector(self, layer_idx: int):
                return np.array(
                        [(
                                np.dot(
                                        np.transpose(self.layers[layer_idx].
 ↪weights),
```

```
                                        self.layers[layer_idx-1].values[0]
                                ) + self.layers[layer_idx].bias_weights
                        ).tolist()],
                        dtype=float
                )

        def net_value_batch(self, layer_idx):
                return np.dot(
                        self.layers[layer_idx - 1].values,
                        self.layers[layer_idx].weights) + self.
↪layers[layer_idx].bias_weights

        def layer_value(self, layer_idx: int):
                layer = self.layers[layer_idx]

                if len(self.layers[layer_idx - 1].values) == 1:
                        layer.values = self.net_value_vector(layer_idx)
                else:
                        layer.values = self.net_value_batch(layer_idx)

                if layer.activation_func == ActivationFunction.LINEAR:
                        layer.values = self.linear_activation(layer.values)
                elif layer.activation_func == ActivationFunction.SIGMOID:
                        layer.values = self.sigmoid_activation(layer.values)
                elif layer.activation_func == ActivationFunction.RELU:
                        layer.values = self.relu_activation(layer.values)
                elif layer.activation_func == ActivationFunction.SOFTMAX:
                        layer.values = self.softmax_activation(layer.values)

        def linear_activation(self, net_mat):
                return net_mat

        def sigmoid_activation(self, net_mat):
                dim = Utils.matrix_dimension(net_mat)
                for i in range(dim[0]):
                        for j in range(dim[1]):
                                net_mat[i][j] = 1 / (1 + math.exp(-1 *␣
↪net_mat[i][j]))
                return net_mat

        def relu_activation(self, net_mat):
                dim = Utils.matrix_dimension(net_mat)
                for i in range(dim[0]):
                        for j in range(dim[1]):
                                net_mat[i][j] = max(0, net_mat[i][j])
                return net_mat
```

```
    def softmax_activation(self, net_mat):
        dim = Utils.matrix_dimension(net_mat)
        sum_exp = []
        for i in range(dim[0]):
            sum = 0
            for j in range(dim[1]):
                sum += math.exp(net_mat[i][j])
            sum_exp.append(sum)

        for i in range(dim[0]):
            for j in range(dim[1]):
                net_mat[i][j] = math.exp(net_mat[i][j]) / sum_exp[i]

        return net_mat

    def predict(self, input):
        np_input = np.array(input)
        if len(np_input.shape)==1:
            self.layers[0].values = [input]
        else:
            self.layers[0].values = input

        self.layers[0].num_nodes = len(input)
        for i in range(1, len(self.layers)):
            self.layer_value(i)
        res = self.layers[len(self.layers) - 1].values

        if len(res) == 1:
            return res[0]
        else:
            return res

    def load_graph(self, filename):
        '''
        load a json file to Graph
        '''
        data = Utils.parse_json(filename) # parse from json
        for layer in data["layers"]:
            type = Utils.get_layer_type(layer["type"])
            if type != LayerType.INPUT:
                act = Utils.get_activation_func(layer["activation_func"])

            if type:
                new_layer = Layer(
```

```
                                      weights=layer["weights"] if type !=␣
↪LayerType.INPUT else None,
                                      bias_weights=layer["bias_weights"] if␣
↪type != LayerType.INPUT else None,
                                      values=[] if type == LayerType.INPUT␣
↪else [0]*layer["num_nodes"],
                                      layer_type=type,
                                      label=layer["label"],
                                      num_nodes=layer["num_nodes"] if type!
↪=LayerType.INPUT else None,
                                      activation_func=act if type !=␣
↪LayerType.INPUT else None)
                              self.add_layer(new_layer)

      def visualize(self, filename="data/plot.png"):
              visual = nx.DiGraph()

              for i in range(len(self.layers)):
                      layer = self.layers[i]
                      visual.add_node(layer.label, pos=(0, i))

              nodes = list(visual.nodes)
              for i in range(len(nodes)):
                      try:
                              visual.add_edge(nodes[i], nodes[i+1])
                      except:
                              pass

              pos = nx.get_node_attributes(visual, "pos")

              nx.draw(
                      visual,
                      pos=pos,
                      edge_color="black",
                      width=1,
                      linewidths=1,
                      node_size=500,
                      node_color="pink",
                      with_labels = True)

              edges = list(visual.edges)
              labels = dict()
              for i in range(len(edges)):
                      labels[edges[i]]= "w_[{}{}]".format(list(edges[i])[0],␣
↪list(edges[i])[1])
```

```
            nx.draw_networkx_edge_labels(
                    visual,
                    pos,
                    edge_labels=labels,
                    font_color="red",
                    rotate=False)
            # plt.pyplot.show()

            if os.path.exists(filename): os.remove(filename)
            plt.pyplot.savefig(filename)

    def display_table(self):
            count = 0
            for index, layer in enumerate(self.layers):
                    print("------------------------------")
                    print("Layer: {}".format(index))

                    print("Layer Type: {}".format(layer.type))
                    print("Values:")
                    print(layer.values)
                    if layer.type != LayerType.INPUT:
                            print("Weight: ")
                            print(layer.weights)

                            print("Bias: ")
                            print(layer.bias_weights)

                            print("Activation Function: {}".format(layer.
↪activation_func))

                    if (layer.type == LayerType.HIDDEN):
                            count+=1

            print("------------------------------")
            print("Output: ")
            if (len(self.layers[0].values) != 0):
                    print(self.predict(self.layers[0].values))
            else:
                    print("No input")
            print("Number of hidden layers: {}".format(count))
```

1.7 Main Function

1.7.1 XOR Sigmoid Model

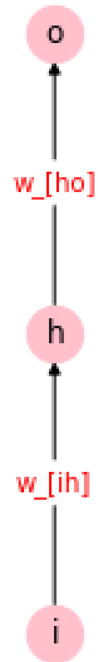
[373]:
```
np.set_printoptions(suppress=True)
graphSigmoid = Graph()
graphSigmoid.load_graph('data/xor_sigmoid.json')
```

1.7.2 Visualisasi Model

[374]:
```
graphSigmoid.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[0. 0.]
Weight:
[[ 20. -20.]
 [ 20. -20.]]
Bias:
[-10.  30.]
Activation Function: sigmoid
------------------------------
Layer: 2
Layer Type: output
Values:
[0.]
Weight:
[[20.]
 [20.]]
Bias:
[-30.]
Activation Function: sigmoid
------------------------------
Output:
No input
Number of hidden layers: 1
```

[375]:
```
graphSigmoid.visualize()
```



Input 1 Instance

[376]:
```
graphSigmoid.predict([0,0])
graphSigmoid.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[[0, 0]]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[[0.0000454 1.        ]]
Weight:
[[ 20. -20.]
 [ 20. -20.]]
Bias:
[-10.  30.]
Activation Function: sigmoid
------------------------------
Layer: 2
Layer Type: output
```

```
Values:
[[0.00004544]]
Weight:
[[20.]
 [20.]]
Bias:
[-30.]
Activation Function: sigmoid
------------------------------
Output:
[0.00004544]
Number of hidden layers: 1
```

Input batch

[377]:
```python
graphSigmoid.predict([[0,0],[0,1],[1,0],[1,1]])
graphSigmoid.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[[0, 0], [0, 1], [1, 0], [1, 1]]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[[0.0000454 1.       ]
 [0.9999546 0.9999546]
 [0.9999546 0.9999546]
 [1.        0.0000454]]
Weight:
[[ 20. -20.]
 [ 20. -20.]]
Bias:
[-10.  30.]
Activation Function: sigmoid
------------------------------
Layer: 2
Layer Type: output
Values:
[[0.00004544]
 [0.99995452]
 [0.99995452]
 [0.00004544]]
Weight:
[[20.]
 [20.]]
```

```
Bias:
[-30.]
Activation Function: sigmoid
------------------------------
Output:
[[0.00004544]
 [0.99995452]
 [0.99995452]
 [0.00004544]]
Number of hidden layers: 1
```

1.7.3 XOR Relu-Linear Model

[378]:
```python
graphRelu = Graph()
graphRelu.load_graph('data/xor_relu_linear.json')
```

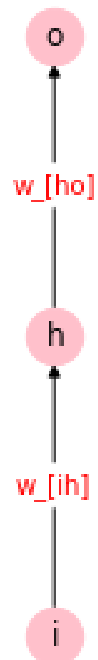
Visualisasi Model

[379]:
```python
graphRelu.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[0. 0.]
Weight:
[[1. 1.]
 [1. 1.]]
Bias:
[ 0. -1.]
Activation Function: relu
------------------------------
Layer: 2
Layer Type: output
Values:
[0.]
Weight:
[[ 1.]
 [-2.]]
Bias:
[0.]
Activation Function: linear
------------------------------
```

```
Output:
No input
Number of hidden layers: 1
```

[380]:
```
graphRelu.visualize()
```



Input 1 Instance

[381]:
```
graphRelu.predict([0,0])
graphRelu.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[[0, 0]]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[[0. 0.]]
Weight:
[[1. 1.]
 [1. 1.]]
```

```
Bias:
[ 0. -1.]
Activation Function: relu
------------------------------
Layer: 2
Layer Type: output
Values:
[[0.]]
Weight:
[[ 1.]
 [-2.]]
Bias:
[0.]
Activation Function: linear
------------------------------
Output:
[0.]
Number of hidden layers: 1
```

Input Batch

[382]:
```
graphRelu.predict([[0,0],[0,1],[1,0],[1,1]])
graphRelu.display_table()
```

```
------------------------------
Layer: 0
Layer Type: input
Values:
[[0, 0], [0, 1], [1, 0], [1, 1]]
------------------------------
Layer: 1
Layer Type: hidden
Values:
[[0. 0.]
 [1. 0.]
 [1. 0.]
 [2. 1.]]
Weight:
[[1. 1.]
 [1. 1.]]
Bias:
[ 0. -1.]
Activation Function: relu
------------------------------
Layer: 2
Layer Type: output
Values:
[[0.]
```

```
 [1.]
 [1.]
 [0.]]
Weight:
[[ 1.]
 [-2.]]
Bias:
[0.]
Activation Function: linear
------------------------------
Output:
[[0.]
 [1.]
 [1.]
 [0.]]
Number of hidden layers: 1
```