My Project

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Chapter 1

README

README
Tested on Ubuntu 20 and python>=3.8
This work is done for the CSE600A (Object Oriented Programming and Design) course requirement for group number 41. The problem statement is given in problem.pdf.

1.0.0.1 Overview

1. In this work we implement a simple 2 layer feed-forward arrtificial neural network (ANN) from scratch using numpy only. Gradients are calculated are calculated similarly to this work: http://cs231n.↩ stanford.edu/slides/2021/discussion_2_backprop.pdf.
2. Doxygen file is at latex/refman.pdf
3. For the profiler file refer to the test/test.txt
4. ann/example2l (2l = 2 layer) class has the implementation of training and testing of the 2 layer network.
5. We achieve an accuracy of 95 percent when trained for 1 epoch.
6. Data and output predictions are in data folder (after you erxtract the data.tar.gz).

1.0.0.2 Model specifications

```
i_d = 784 # input dimension
m_d = 100 # no of cells in the mid layer
o_d = 10 # output dimension
epoch = 1 # we train for 1 epoch only
act = 'relu' # activation type
lr = 0.00001 # learning rate
X,Y,X_test,Y_test = train_features, train_label, test_features, test_label
```

1.0.0.3 Run these commands to set up the environment. Conda need to be installed. If not than you have to manually install the dependencies.

```
conda env create -f environment.yml
conda activate oopd
python setup.py sdist bdist_wheel
pip install dist/ann-0.0.1-py3-none-any.whl
```

1.0.0.4 Run these commands to extract the MNIST dataset and to train the example network on it.

```
tar -xvf data.tar.gz
```

This will extract the database required to train the network on MNIST dataset.

```
python run.py
```

After the traning the predicions and their true values will be saved in data/test_pred_true.csv file. To conver this into a sql database run the below commands.

1.0.0.5 Run these commands to save the prediction to a sql database.

```
.mode csv
.import data/test_pred_true.csv oopd
.save data/oopd_pred_true.db
```

Chapter 2

Namespace Index

2.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

Chapter 3

Hierarchical Index

3.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 4

Class Index

4.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 5

Namespace Documentation

5.1 ann.activation Namespace Reference

Classes

- class Relu
- class Sigmoid

5.1.1 Detailed Description

```
@package docstring
This module contains the different activation functions used in AI.
```

5.2 ann.data Namespace Reference

Classes

- class Mnist

5.2.1 Detailed Description

```
@package docstring
This module contains the different dataset download functions.
```

5.3 ann.layer Namespace Reference

Classes

- class Linear

5.3.1 Detailed Description

```
@package docstring
This module contains all the different layers used in neural networks
```

5.4 ann.loss Namespace Reference

Classes

- class Cross_Ent_Loss

5.4.1 Detailed Description

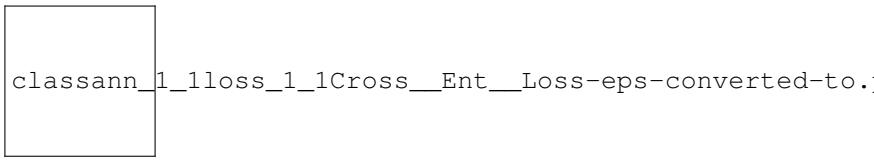
```
@package docstring
This module contains all the los functions
```

Chapter 6

Class Documentation

6.1 ann.loss.Cross_Ent_Loss Class Reference

Inheritance diagram for ann.loss.Cross_Ent_Loss:



Public Member Functions

- def forward_loss (self, logits, true)
- def backward_loss (self)
- def softmax (self, x)

Public Attributes

- **pred**
- **true**
- **z**

6.1.1 Detailed Description

```
Applies the combined cross entropy and softmax loss function element-wise.
For easier backprop calculation.

Args:
    None
```

6.1.2 Member Function Documentation

6.1.2.1 backward_loss()

```
def ann.loss.Cross_Ent_Loss.backward_loss (
              self )
```

Implements the backprop calculation.

6.1.2.2 forward_loss()

```
def ann.loss.Cross_Ent_Loss.forward_loss (
              self,
              logits,
              true )
```

Args:
    logits: Predicted vector of shape [num_classes,1].
    true: truth vector of shape [num_classes,1].

6.1.2.3 softmax()

```
def ann.loss.Cross_Ent_Loss.softmax (
              self,
              x )
```

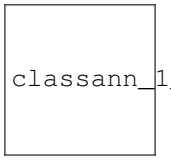
Implements the softmax function element wise.

The documentation for this class was generated from the following file:

- ann/loss.py

6.2 ann.layer.Linear Class Reference

Inheritance diagram for ann.layer.Linear:



Public Member Functions

- def **__init__** (self, i_d, o_d)
- def forward_l (self, x)
- def backward_l (self, x)
- def update_l (self, alpha)
- def reset_l (self)

Public Attributes

- **weight**
- **bias**
- **weight_grad**
- **bias_grad**
- **x**

6.2.1 Detailed Description

```
This class implements the linear layer.

Args:
    i_d > input dimension
    o_d > output dimension

Attributes:
    weight: the learnable weight of the module.
    bias: the learnable bias of the module.

    weight_grad: gradient for the weight matrix.
    bias_grad: gradient for the bias matrix.

Examples:
 >>>> m = ann.Linear(10,20)
 >>>> inp = np.random.rand(i_d,1)
 >>>> out = m.forward(inp)
 >>>> out.shape
 [o_d,1]
```

6.2.2 Member Function Documentation

6.2.2.1 backward_l()

```
def ann.layer.Linear.backward_l (
              self,
              x )
```

```
Implements the  Backprop calculations given the gradeints.
```

6.2.2.2 forward_l()

```
def ann.layer.Linear.forward_l (
              self,
              x )
```

```
Implements the forward calculation given an input.

Input: matrix with shape [dim,1]
ouput: matrix with shape [o_d,1]
```

6.2.2.3 reset_l()

```
def ann.layer.Linear.reset_l (
              self )
```

```
To reset the gradients to zero.
```

6.2.2.4 update_l()

```
def ann.layer.Linear.update_l (
              self,
              alpha )
```

```
To update the Gradients of each layer.
```

The documentation for this class was generated from the following file:

- ann/layer.py

6.3 ann.data.Mnist Class Reference

Public Member Functions

- def **__init__** (self, path)
- def from_sql (self, train_db='oopd_train.db', test_db='oopd_test.db')
- def data (self)
- def fetch (self, url)
- def sql_database (self, path_to_db)

Public Attributes

- **path**

6.3.1 Detailed Description

```
Download the MNIST dataset and load it in a required format.

Args:
    path: where to save the dataset.

Return:
    X: training input [60000,784]
    Y: training output [60000,1]

    X_test = test input [10000,784]
    Y_test = test output [10000,1]
```

6.3.2 Member Function Documentation

6.3.2.1 data()

```
def ann.data.Mnist.data (
              self )
```

```
Download the data from source
Save it to the disk in self.path/ directory
```

6.3.2.2 fetch()

```
def ann.data.Mnist.fetch (
              self,
              url )
```

```
Downloads the MNIST data given the url.
```

6.3.2.3 from_sql()

```
def ann.data.Mnist.from_sql (
              self,
              train_db = 'oopd_train.db',
              test_db = 'oopd_test.db' )
```

```
Load from a given sql database.
```

6.3.2.4 sql_database()

```
def ann.data.Mnist.sql_database (
              self,
              path_to_db )
```

Read the data from a sql database.

The documentation for this class was generated from the following file:

- ann/data.py

6.4 ann.example2l.Net Class Reference

Inheritance diagram for ann.example2l.Net:

Public Member Functions

- def __init__ (self, i_d, m_d, o_d, act, lr, epoch, X, Y, X_test, Y_test)
- def forward (self, x)
- def backward (self)
- def update (self)
- def reset (self)
- def loss (self, pred, index)
- def evaluate (self, X=None, Y=None, save=True)
- def train (self, step_u=1, step=100000, test=False)

Public Attributes

- **alpha**
- **epoch**
- **layer1**
- **act1**
- **layer2**
- **cross_ent_loss**
- **Y**
- **Y_test**
- **X_test**

6.4.1 Detailed Description

```
Inheritance, Encapsulation, Polymorphism.
Create a 2 layer feed forward artifical neural network (ANN).

Args:
    i_d: input dimension.
    m_d: number of cells in 1st layer.
    o_d: output dimension.
    act: activation function to use.
    lr: Learning rate
    epoch: number of epochs to train.
    X: training input [60000,784].
    Y: training output [60000,1].
    X_test = test input [10000,784].
    Y_test = test output [10000,1].

Returns:
    None

Example:
    i_d, m_d, o_d = 784, 100, 10
    act = 'relu'
    lr,epoch = 0.00001,10
    X,Y,X_test,Y_test = data.Mnist(path='data').data()
    net = example2l.Net(i_d,m_d,o_d,act, lr,epoch, X,Y,X_test,Y_test)
    net.train()
```

6.4.2 Constructor & Destructor Documentation

6.4.2.1 __init__()

```
def ann.example2l.Net.__init__ (
              self,
              i_d,
              m_d,
              o_d,
              act,
              lr,
              epoch,
              X,
              Y,
              X_test,
              Y_test )
```

Reimplemented from ann.layer.Linear.

6.4.3 Member Function Documentation

6.4.3.1 backward()

```
def ann.example2l.Net.backward (
              self )
```

Calls backprop fucntion for each layer to calculate the gradients.

6.4.3.2 evaluate()

```
def ann.example2l.Net.evaluate (
              self,
              X = None,
              Y = None,
              save = True )
```

Evaulate the created model given the test data.

6.4.3.3 forward()

```
def ann.example2l.Net.forward (
              self,
              x )
```

Calls the forward fucntion for each layer.

6.4.3.4 loss()

```
def ann.example2l.Net.loss (
              self,
              pred,
              index )
```

Calculate the cross entropy loss.

6.4.3.5 reset()

```
def ann.example2l.Net.reset (
              self )
```

Calls the reset fucntion of each layer to reset the gradients back to 0.

6.4.3.6 train()

```
def ann.example2l.Net.train (
              self,
              step_u = 1,
              step = 100000,
              test = False )
```

Train the created model given the input.

6.4.3.7 update()

```
def ann.example2l.Net.update (
              self )
```

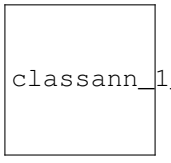
Calls the update fucntion of each layer to update the gradients.

The documentation for this class was generated from the following file:

- ann/example2l.py

6.5 ann.activation.Relu Class Reference

Inheritance diagram for ann.activation.Relu:



Public Member Functions

- def forward_a (self, x)
- def backward_a (self, x)

Public Attributes

- **z**

6.5.1 Detailed Description

```
Applies the rectified linear unit function element-wise.

Args:
    None
```

6.5.2 Member Function Documentation

6.5.2.1 backward_a()

```
def ann.activation.Relu.backward_a (
              self,
              x )
```

```
Implements the backprop calculation.
```

6.5.2.2 forward_a()

```
def ann.activation.Relu.forward_a (
              self,
              x )
```

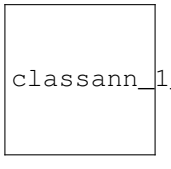
```
Implements the Forward calculation given an input.
```

The documentation for this class was generated from the following file:

- ann/activation.py

6.6 ann.activation.Sigmoid Class Reference

Inheritance diagram for ann.activation.Sigmoid:



Public Member Functions

- def forward_a (self, x)
- def backward_a (self, x)

Public Attributes

- **z**

6.6.1 Detailed Description

```
Applies the sigmoid function element-wise.

Args:
    None
```

6.6.2 Member Function Documentation

6.6.2.1 backward_a()

```
def ann.activation.Sigmoid.backward_a (
              self,
              x )
```

```
Implements the backprop calculation.
```

6.6.2.2 forward_a()

```
def ann.activation.Sigmoid.forward_a (
              self,
              x )
```

```
Implements the Forward calculation given an input.
```

The documentation for this class was generated from the following file:

- ann/activation.py