# My Project

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# Chapter 1

# Tesdted on Ubuntu 20 and python>=3.8

#### 1.0.0.0.1 This project is done for the CSE600A (Object Oriented Programming and Design) course requirement.

## 1.0.1 Overview

1. In this work we implement a simple 2 layer feed forwad arrtificial neural netowork (ANN) from scratch using numpy only. Gradients are calculated locally and passed for downstream calculations similarly to this work: http://cs231n.stanford.edu/slides/2021/discussion_2_backprop.pdf.
2. For the hierchy of different classes refer to the latex/refman.pdf file.
3. For the profiler file refer to the test/test.txt

#### 1.0.1.1 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 trainn 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. example2l (2l $>$ 2 layer) class has implements the training and testting of the 2 layer network.

2. We achieve an accuracy of 95 percent with these hyperparameters.

## 1.0.2 Run these commands to set up the environment. We need conda to be installed. If not than you have to manually install the dependencies.

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

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

```
tar -xvf data.tar.gz <br/>
python run.py
```

### 1.0.4 Run these commands to save the prediction to a sql database.

```
.mode csv <br/>
.import data/test_pred_true.csv oopd <br/>
.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

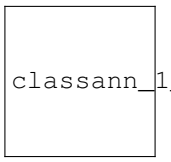
```
@package docstring
This module contains all the los functions
```

# 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)
- 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() [1/2]

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

Implements the backprop calculation.

#### 6.1.2.2 backward_loss() [2/2]

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

Implements the backprop calculation.

#### 6.1.2.3 forward_loss() [1/2]

```
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].
```

#### 6.1.2.4 forward_loss() [2/2]

```
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].
```

#### 6.1.2.5 softmax() [1/2]

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

Implements the softmax dunction element wise.
```

#### 6.1.2.6 softmax() [2/2]

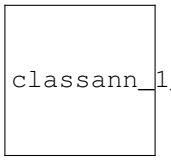
```
def ann.loss.Cross_Ent_Loss.softmax (
              self,
              x )

Implements the softmax dunction element wise.
```

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

- ann/loss.py
- build/lib/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)
- 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 leranable weight of the module.
    bias: the leranable 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() [1/2]

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

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

### 6.2.2.2 backward_l() [2/2]

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

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

#### 6.2.2.3 forward_l() [1/2]

```
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]

#### 6.2.2.4 forward_l() [2/2]

```
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]

#### 6.2.2.5 reset_l() [1/2]

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

To reset th gradients to zero.

#### 6.2.2.6 reset_l() [2/2]

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

To reset th gradients to zero.

#### 6.2.2.7 update_l() [1/2]

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

To update the Gradients of each layer.

#### 6.2.2.8 update_l() [2/2]

```
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 files:

- ann/layer.py
- build/lib/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)
- 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 save them in a given path.

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() [1/2]

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

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

#### 6.3.2.2 data() [2/2]

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

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

#### 6.3.2.3 fetch() [1/2]

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

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

#### 6.3.2.4 fetch() [2/2]

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

Downloads the MNIST data given the url.

#### 6.3.2.5 from_sql() [1/2]

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

Upload the load from a sql database

#### 6.3.2.6 from_sql() [2/2]

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

Upload the load from a sql database

#### 6.3.2.7 sql_database() [1/2]

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

Read the data from a sql database.

#### 6.3.2.8 sql_database() [2/2]

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

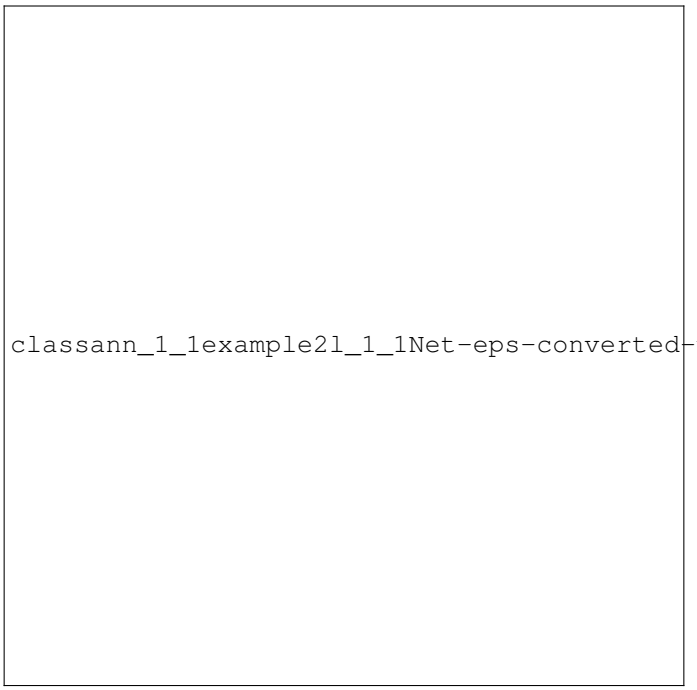
Read the data from a sql database.

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

- ann/data.py
- build/lib/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)
- 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

```
Create a sample 2 layer feed forward artitifical 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__() [1/2]

```
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.

#### 6.4.2.2 __init__() [2/2]

```
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() [1/2]

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

Calls backprop fucntion for each layer to calculate the gradients.

#### 6.4.3.2 backward() [2/2]

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

Calls backprop fucntion for each layer to calculate the gradients.

#### 6.4.3.3 evaluate() [1/2]

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

Evaulate the created model given the test data.

#### 6.4.3.4 evaluate() [2/2]

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

Evaulate the created model given the test data.

#### 6.4.3.5 forward() [1/2]

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

Calls the forward fucntion for each layer.

#### 6.4.3.6 forward() [2/2]

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

Calls the forward fucntion for each layer.

#### 6.4.3.7 loss() [1/2]

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

Calculate the cross entropy loss.

#### 6.4.3.8 loss() [2/2]

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

Calculate the cross entropy loss.

#### 6.4.3.9 reset() [1/2]

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

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

#### 6.4.3.10 reset() [2/2]

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

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

#### 6.4.3.11 train() [1/2]

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

Train the created model given the input.

#### 6.4.3.12 train() [2/2]

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

Train the created model given the input.

#### 6.4.3.13 update() [1/2]

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

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

#### 6.4.3.14 update() [2/2]

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

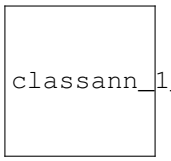
Calls the update fucntion of each layer to update the gradients.

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

- ann/example2l.py
- build/lib/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)
- 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() [1/2]

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

```
Implements the backprop calculation.
```

#### 6.5.2.2 backward_a() [2/2]

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

Implements the backprop calculation.

#### 6.5.2.3 forward_a() [1/2]

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

Implements the Forward calculation given an input.

#### 6.5.2.4 forward_a() [2/2]

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

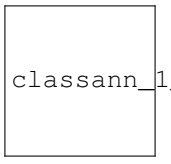
Implements the Forward calculation given an input.

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

- ann/activation.py
- build/lib/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)
- 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() [1/2]

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

```
Implements the backprop calculation.
```

#### 6.6.2.2 backward_a() [2/2]

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

```
Implements the backprop calculation.
```

#### 6.6.2.3 forward_a() [1/2]

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

Implements the Forward calculation given an input.

#### 6.6.2.4 forward_a() [2/2]

```
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 files:

- ann/activation.py
- build/lib/ann/activation.py