Run CNN+RayBNN on CCDB

Package RayBNN_python

Source Code For RayBNN v2.0.1

https://github.com/BrosnanYuen/RayBNN_Neural

https://github.com/BrosnanYuen/RayBNN_DataLoader

https://github.com/BrosnanYuen/RayBNN_Sparse

https://github.com/BrosnanYuen/RayBNN_Raytrace

https://github.com/BrosnanYuen/RayBNN_Python

https://github.com/BrosnanYuen/RayBNN_Cell

https://github.com/BrosnanYuen/RayBNN_Optimizer

Git clone RayBNN_Python

```
# Load modules
#module --force purge
module load StdEnv/2020 gcc/9.3.0 cuda/12.2 fmt/9.1.0 spdlog/1.9.2 arrayfire/3.9.0 rust/1.70.0 python/3.11.2 openblas
```

Load necessary module(I add openblas)

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Package RayBNN_python(cont.)

```
virtualenv magic
source magic/bin/activate
pip install maturin numpy patchelf
```

install dependencies in the virtual environment

```
maturin develop
echo "maturin success"
```

use maturin to package Rust code into python wheel

```
(magic) [lain1385@narval3 CNN]$ pip list
Package           Version                   Editable project location
----------------- ------------------------- ---------------------------------------------------------
python_dateutil   2.9.0.post0+computecanada
raybnn_python     0.1.2                     /lustre07/scratch/lain1385/project/RayBNN_Python/Rust_Code
requests          2.32.3
```

Check that raybnn_python is installed successfully as python module

This process doesn't need to be submitted to compute cluster

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Package RayBNN_python(cont.)

```
project > RayBNN_Python > Rust_Code > example.py
1   import numpy as np
2   import raybnn_python
```

```
13  print("Rust")
14
15  z = raybnn_python.magic2(x)
16
17  print(z)
```

Try RayBNN_Python/Rust_Code/example.py to validate raybnn_python package

```
0.602763    0.891773    0.568045
0.832620    0.461479    0.944669

0.544883    0.963663    0.925597
0.778157    0.780529    0.521848

0.423655    0.383442    0.071036
0.870012    0.118274    0.414662


b
[1 1 1 1]
   0.778157
[[[0.5488135  0.71518934 0.60276335 0.5448832  0.4236548 ]
  [0.6458941  0.4375872  0.891773   0.96366274 0.3834415 ]
  [0.79172504 0.5288949  0.56804454 0.92559665 0.07103606]]

 [[0.0871293  0.0202184  0.83261985 0.77815676 0.87001216]
  [0.9786183  0.7991586  0.46147937 0.7805292  0.11827443]
  [0.639921   0.14335328 0.9446689  0.5218483  0.41466194]]]
0.77815676
Rust
{'dtype': 'F32', 'shape': {'dims': (2, 3, 5, 1)}, 'data': [0.54881352186203, 0.08712930232286453, 0.64
```

Submit jobs to run example.py and ouput is shown above

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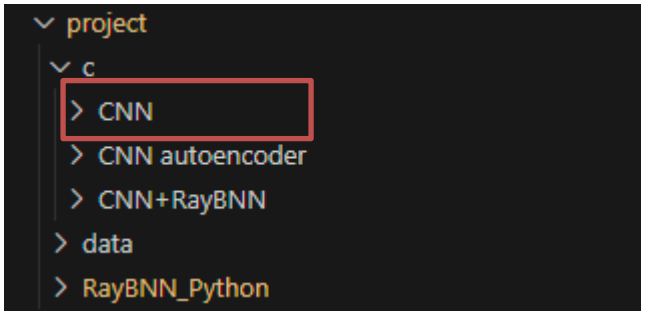
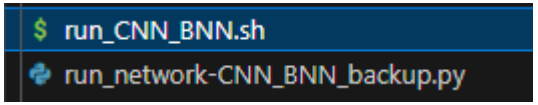
Try code from Xuan



Download code of Xuan and unzip it (using Globus to transfer it onto CCDB)



Try to run C/CNN Code

```
if __name__ == '__main__':

    val_features, val_labels, train_features, train_labels = main()

    output_y = train_raybnn(train_features, train_labels, val_features, val_labels)
```

Use CNN model to extract features and labels

Then apply raybnn to train it

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Prepare Dataset

```python
import numpy as np
import raybnn_python
import torch
from torch import nn, optim
from PIL import Image
import matplotlib.pyplot as plt
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_recall_fscore_support
from sklearn.model_selection import KFold
import os
from torchvision import datasets, transforms,utils
from torch.utils.data import ConcatDataset, Subset, DataLoader
from torch import optim
import torch.nn.functional as F

```

Pip install necessary packages in the virtual environment

```python
full_dataset = ConcatDataset([
    datasets.MNIST(root="/home/lain1385/scratch/project/data", transform=transform, train=True, download=True),
    datasets.MNIST(root="/home/lain1385/scratch/project/data", transform=transform, train=False, download=True)
])
```

Set download=True to automatically download MNIST Dataset

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CNN module

```python
class CNN(nn.Module):
    def __init__(self, input_dim, output_dim, feature_dim):
        super(CNN, self).__init__()
        self.conv1 = nn.Conv2d(input_dim[0], 5, kernel_size=3, stride=1, padding=1)
        self.pool = nn.MaxPool2d(2, 2)
        self.conv2 = nn.Conv2d(5, 10, kernel_size=3, stride=1, padding=1)
        self.flatten = nn.Flatten()
        latent_shape = self._get_conv_shape(input_dim=input_dim)
        self.fc1 = nn.Linear(latent_shape[1], 1024)
        self.fc2 = nn.Linear(1024, 512)
        self.fc3 = nn.Linear(512, 10)
        self.dropout = nn.Dropout(0.5)
```

layer setting

(I reduced kernel channel)

conv1: convolution layer with5 output channels, a kernel size of 3x3, stride of 1, and padding of 1.

pool: A max pooling layer with a kernel size of 2x2 and a stride of 2.

flatten: A layer that flattens the input

fc1: A fully connected (linear) layer

For extracted feature: image pixel -> conv1 -> pool -> conv2 -> flatten

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CNN output

```
val_features, val_labels, train_features, train_labels = main()
np.save('val_features.npy',val_features)
np.save('val_labels.npy',val_labels)
np.save('train_features.npy',train_features)
np.save('train_labels.npy',train_labels)
```

Save output data

```
val_features: (2000, 490)

val_labels: (2000,)

train_features: (8000, 490)

train_labels: (8000,)
```

Check shape of features & labels after CNN

(# of samples set to 10000)

Original features dimension: 3136

Features dimension after modification: 490

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CNN output

```
Epoch [1/10], Loss: 1.55051, Accuracy: 61.03750%
Epoch [2/10], Loss: 0.61459, Accuracy: 81.88750%
Epoch [3/10], Loss: 0.47207, Accuracy: 85.96250%
Epoch [4/10], Loss: 0.41368, Accuracy: 87.21250%
Epoch [5/10], Loss: 0.36751, Accuracy: 88.97500%
Epoch [6/10], Loss: 0.33736, Accuracy: 89.72500%
Epoch [7/10], Loss: 0.32006, Accuracy: 90.06250%
Epoch [8/10], Loss: 0.29043, Accuracy: 91.11250%
Epoch [9/10], Loss: 0.27371, Accuracy: 91.55000%
Epoch [10/10], Loss: 0.25019, Accuracy: 92.01250%
Fold 1: Accuracy=0.94700, Precision=0.94638, Recall=0.94403, F1 Score=0.94482
Precision: 0.94638, Recall: 0.94403, F1 Score: 0.94482
Epoch [10/10], Test Loss: 0.39262, Test Accuracy: 94.70000%
Epoch [1/10], Loss: 1.47166, Accuracy: 62.33750%
Epoch [2/10], Loss: 0.55135, Accuracy: 82.93750%
```

The output during model training

K fold cross validation: k = 5 (the original is 10)

Epoch = 10

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RaybNN training

```
val_features = np.load('val_features.npy')
val_labels = np.load('val_labels.npy')
train_features = np.load('train_features.npy')
train_labels = np.load('train_labels.npy')

output_y = train_raybnn(train_features, train_labels, val_features, val_labels)
```

Load saved data and invoke function train_raybnn

```
def train_raybnn(x_train, y_train, x_test, y_test):
    accuracy_values = []
    precision_values=[]
    recall_values = []
    f1_values=[]
```

```
dir_path = "/home/lain1385/scratch/project/c/CNN/tmp"

max_input_size = 512
input_size = 490

max_output_size = 10
output_size = 10
```

modify input_size to match CNN output in the function train_raybnn

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RaybNN training ouput

```
******Network Information******
neuron_size: 1000
input_size: 490
output_size: 10
proc_num: 2
active_size: 978
space_dims: 3
step_num: 5000
batch_size: 1000
del_unused_neuron: true
time_step: 0.1
nratio: 0.5
neuron_std: 0.001
sphere_rad: 11.882076
neuron_rad: 0.1
con_rad: 9.190047
init_prob: 0.01
add_neuron_rate: 0
del_neuron_rate: 0
center_const: 0.005
spring_const: 0.01
repel_const: 0.01
***********
```

Parameters of RayBNN training

```
WValues.dims()[0] 80088
Start training
loss: 0.9709589, alpha0: 0.01, i: 0
loss: 0.94332623, alpha0: 0.01, i: 1
/scratch/lain1385/project/RayBNN_Python/magic/lib/pytho
  _warn_prf(average, modifier, msg_start, len(result))
Start training
loss: 0.9438329, alpha0: 0.01, i: 0
loss: 0.8922663, alpha0: 0.01, i: 1
loss: 0.87254024, alpha0: 0.01, i: 2
/scratch/lain1385/project/RayBNN_Python/magic/lib/pytho
  _warn_prf(average, modifier, msg_start, len(result))
Start training
loss: 0.8666107, alpha0: 0.01, i: 0
loss: 0.8581241, alpha0: 0.01, i: 1
loss: 0.7695129, alpha0: 0.01, i: 2
loss: 0.6814341, alpha0: 0.01, i: 3
Start training
loss: 0.68098223, alpha0: 0.01, i: 0
loss: 0.644085, alpha0: 0.01, i: 1
loss: 0.5558632, alpha0: 0.01, i: 2
loss: 0.47429863, alpha0: 0.01, i: 3
loss: 0.40849525, alpha0: 0.01, i: 4
Start training
loss: 0.41367176, alpha0: 0.01, i: 0
loss: 0.4257643, alpha0: 0.01, i: 1
loss: 0.3790139, alpha0: 0.01, i: 2
loss: 0.31628898, alpha0: 0.01, i: 3
loss: 0.3286937, alpha0: 0.01, i: 4
loss: 0.2764489, alpha0: 0.01, i: 5
Start training
```

Loss during RayBNN training

Still working on how to improve performance

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Thank you

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