Machine Learning Assignment

Neural Network

In [133…
```
import numpy as np
import matplotlib.pyplot as plt
import torch
import torch.nn as nn
import torch.optim as optim
from PIL import Image
from IPython.display import display
import torchvision.transforms as visiontrans
```

In [134…
```
def train_nn(hidden_layers):
    model = nn.Sequential(*hidden_layers)

    trns_img = visiontrans.Compose([
    visiontrans.Grayscale(),
    visiontrans.ToTensor()])

    input_pixels = trns_img(Image.open("bird038.png"))

    flattened_pxl = input_pixels.flatten()
    mean_pxl = input_pixels.mean()
    std_pxl = input_pixels.std()
    std_flattened_pxl = (flattened_pxl - mean_pxl) / std_pxl

    x_coordinates = torch.arange(97).float()
    y_coordinates = torch.arange(128).float()
    xx, yy = torch.meshgrid(x_coordinates, y_coordinates)
    coordinates = torch.stack((xx, yy), dim=-1).view(-1, 2)

    coord_mean = coordinates.mean(dim=0)
    coord_std = coordinates.std(dim=0)
    custom_standardized_axis = (coordinates - coord_mean) / coord_std

    custom_standardized_axis = custom_standardized_axis.numpy()
    std_flattened_pxl = std_flattened_pxl.numpy()

    custom_data = list(zip(custom_standardized_axis, std_flattened_pxl))
    np.random.shuffle(custom_data)
    batch_size = 64
    num_batches = len(custom_data) // batch_size

    model.to(torch.device("cuda" if torch.cuda.is_available() else "cpu"))

    adam_optim = optim.Adam(model.parameters(), lr=0.0001)
    loss_fn = nn.MSELoss()
    step_size = 100


    def reduce_learning_rate(optimizer, epoch):
        learning_rate = 0.0001 * (0.5 ** (epoch // step_size))
        for param_group in optimizer.param_groups:
            param_group['lr'] = learning_rate

    epoch_losses = []
```

```
epochs = 300
for epoch in range(epochs):
    for i in range(num_batches):
        start_idx = i * batch_size
        end_idx = (i + 1) * batch_size
        batch_data = custom_data[start_idx:end_idx]
        X_batch, y_batch = zip(*batch_data)
        X_batch = torch.tensor(X_batch).float()
        y_batch = torch.tensor(y_batch).float()
        adam_optim.zero_grad()
        pred = model(X_batch).squeeze()
        loss = loss_fn(pred, y_batch)
        loss.backward()
        adam_optim.step()

    epoch_losses.append(loss.item())
    reduce_learning_rate(adam_optim, epoch)

with torch.set_grad_enabled(False):
    model_output = model(torch.tensor(custom_standardized_axis).float()).cpu()
    processed_image = ((model_output * std_pxl + mean_pxl).clamp(0., 1.) * 255).numpy().astype(np.uint8)
    final_image = Image.fromarray(processed_image.reshape(97, 128))

plt.figure(figsize=(12, 8))
plt.plot(range(1, 301), epoch_losses, color='black', marker='s', markersize=5, linestyle='-', label='Train Loss')
plt.xlabel('epochs')
plt.ylabel('Loss')
plt.title('Loss function v/s Epochs')
plt.legend()
plt.show()

display(final_image)
```

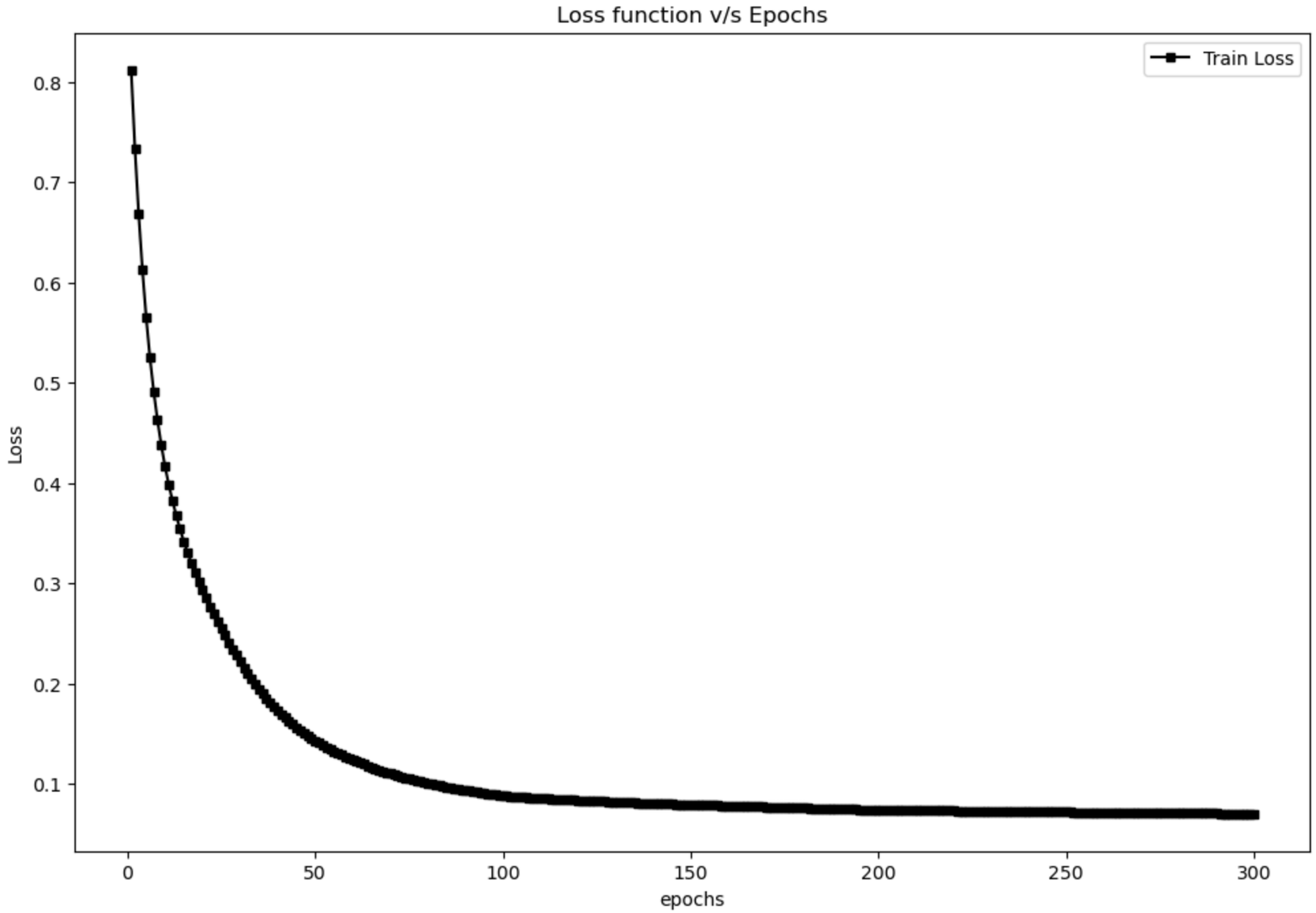
In [135…

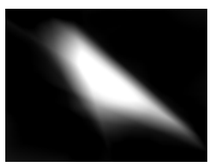
```
hidden_layers = [
    torch.nn.Linear(2,128),
    torch.nn.ReLU(),
    torch.nn.Linear(128,1)
]

print()
print("-------------1A Solution--------------------")
print()

train_nn(hidden_layers)
```

```
-------------1A Solution--------------------
```





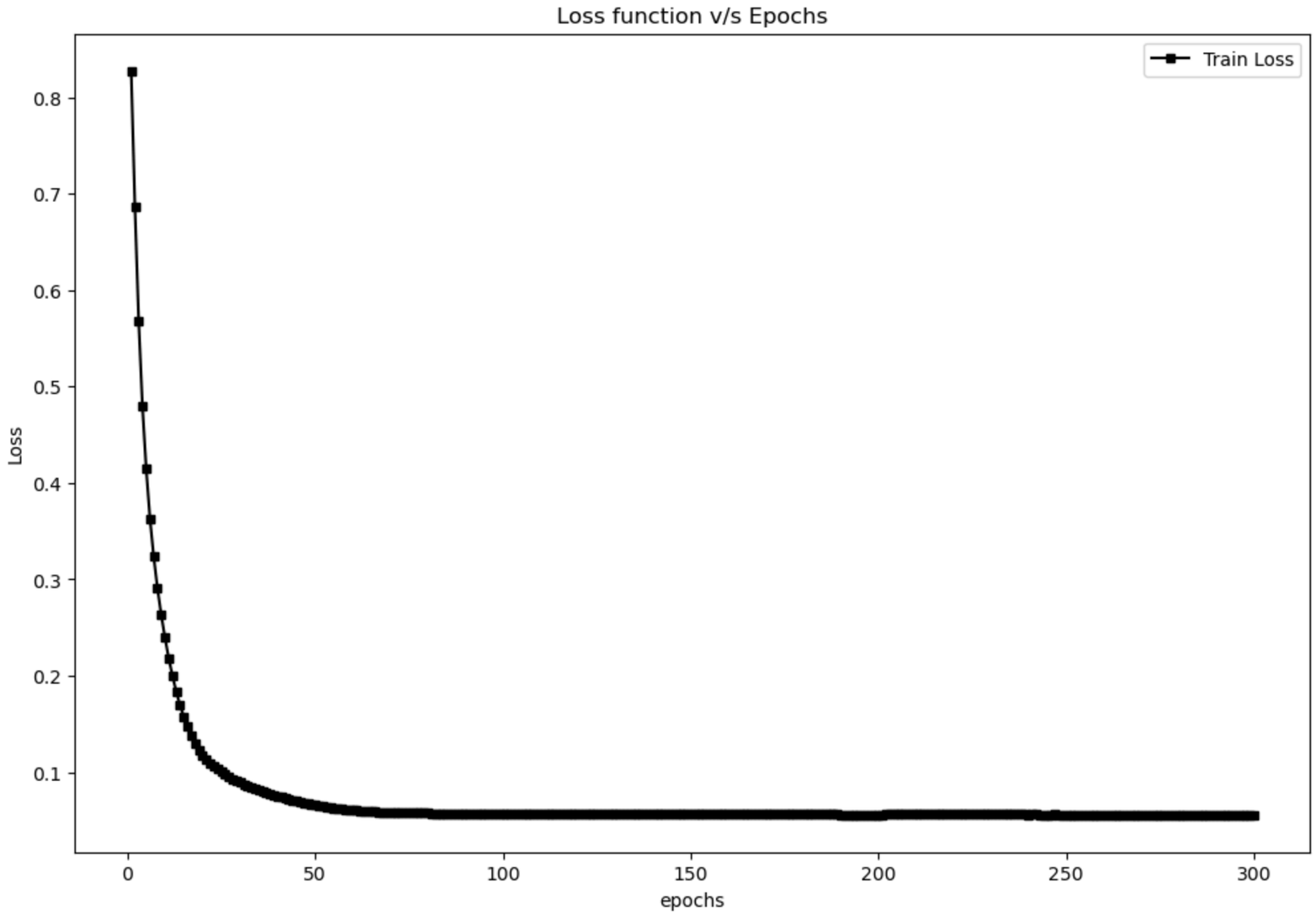
In [136…

```
hidden_layers = [
    nn.Linear(2,32),
    nn.ReLU(),
    nn.Linear(32,128),
    nn.ReLU(),
    nn.Linear(128,1)
]

print()
print("-------------1B Solution--------------------")
print()

train_nn(hidden_layers)
```

```
-------------1B Solution--------------------
```



In [137…

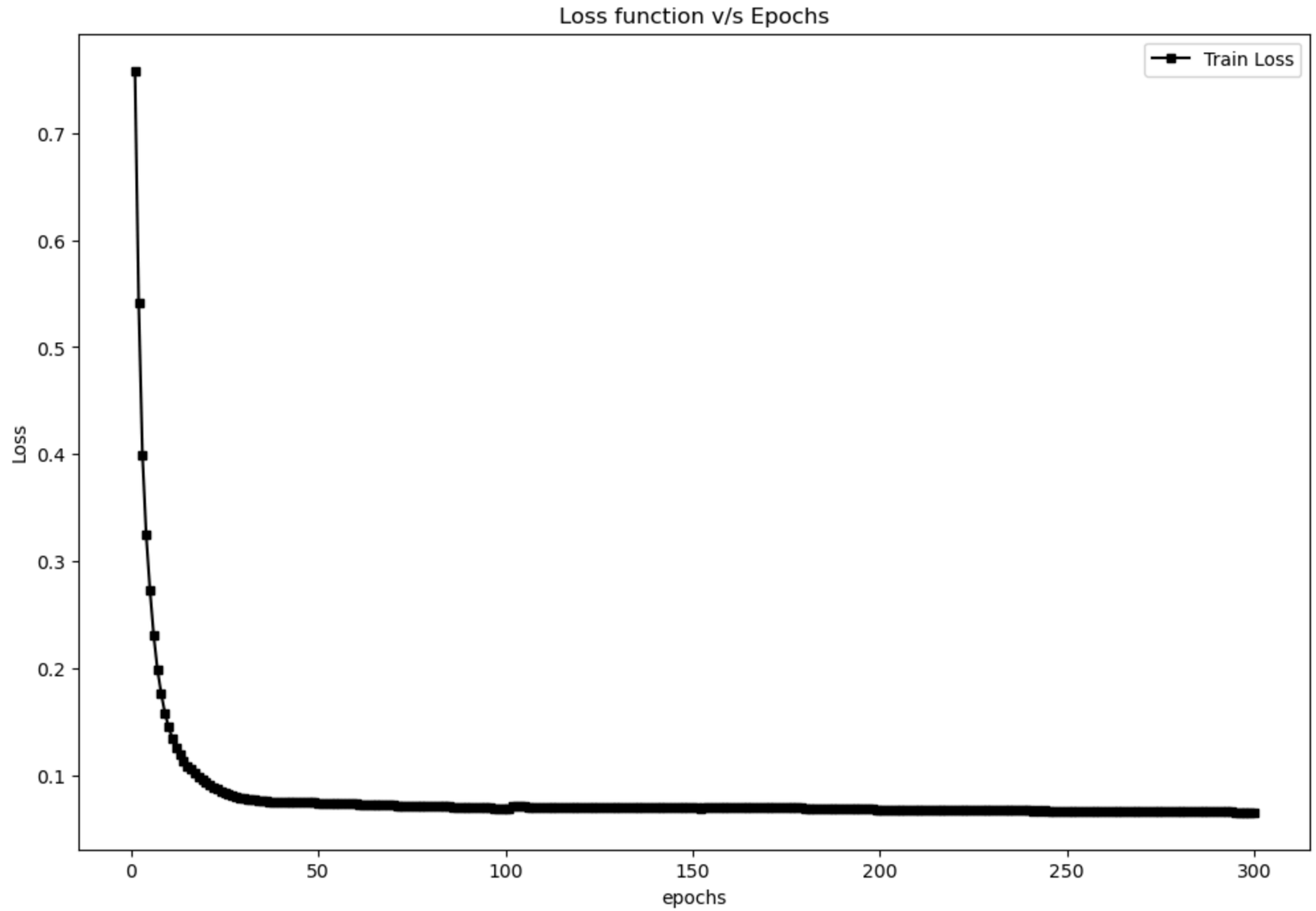
```python
hidden_layers = [
    nn.Linear(2,32),
    nn.ReLU(),
    nn.Linear(32,64),
    nn.ReLU(),
    nn.Linear(64,128),
    nn.ReLU(),
    nn.Linear(128,1)
]

print()
print("-------------1C Solution--------------------")
```

```
print()

train_nn(hidden_layers)
```

```
-------------1C Solution--------------------
```



In [138…

```
hidden_layers = [
    nn.Linear(2,32),
    nn.ReLU(),
    nn.Linear(32,64),
    nn.ReLU(),
    nn.Linear(64,128),
    nn.ReLU(),
    nn.Linear(128,128),
```

```
    nn.ReLU(),
    nn.Linear(128,1)
]

print()
print("-------------1D Solution--------------------")
print()


train_nn(hidden_layers)
```

```
-------------1D Solution--------------------
```