Neural Network Performance Visualization

```
import torch
import torch.nn as nn
from torchvision import datasets, transforms
import pandas as pd
import matplotlib.pyplot as plt
import os
import numpy as np

from src.custom_nn import CustomNeuralNet, train_model, setup_device
```

1 Prepare MNIST dataset

```
device = setup_device()

train_data = datasets.MNIST(root="data", train=True,
transform=transforms.ToTensor(), download=True)
test_data = datasets.MNIST(root="data", train=False,
transform=transforms.ToTensor(), download=True)

mean = train_data.data.float().mean() / 255.0
std = train_data.data.float().std() / 255.0
print(f"Train data mean: {mean:.4f}, std: {std:.4f}")

X_train = ((train_data.data.view(-1, 28*28).float() / 255.0 - mean) /
std).to(device)
y_train = (train_data.targets).to(device)

X_test = ((test_data.data.view(-1, 28*28).float() / 255.0 - mean) /
std).to(device)
y_test = (test_data.targets).to(device)

print("Train data shape:", X_train.shape)
print("Train labels shape:", y_train.shape)
print("Test data shape:", X_test.shape)
print("Test labels shape:", y_test.shape)
```

```
Utilizing device: cuda:0
Train data mean: 0.1307, std: 0.3081
Train data shape: torch.Size([60000, 784])
Train labels shape: torch.Size([60000])
Test data shape: torch.Size([10000, 784])
Test labels shape: torch.Size([10000])
```

2 Define model and train

```
model = CustomNeuralNet(
    sizes=[28*28, 128, 64, 10],  # input → hidden1 → hidden2 → output
    activation=nn.ReLU,
    weight_init="he"
)

train_model(
    model,
    X=X_train,
    y=y_train,
    epochs=30,
    batch=64,
    lr=0.01,
    val_fraction=0.3,
    patience=5
)
```

3 Load results.csv for visualization

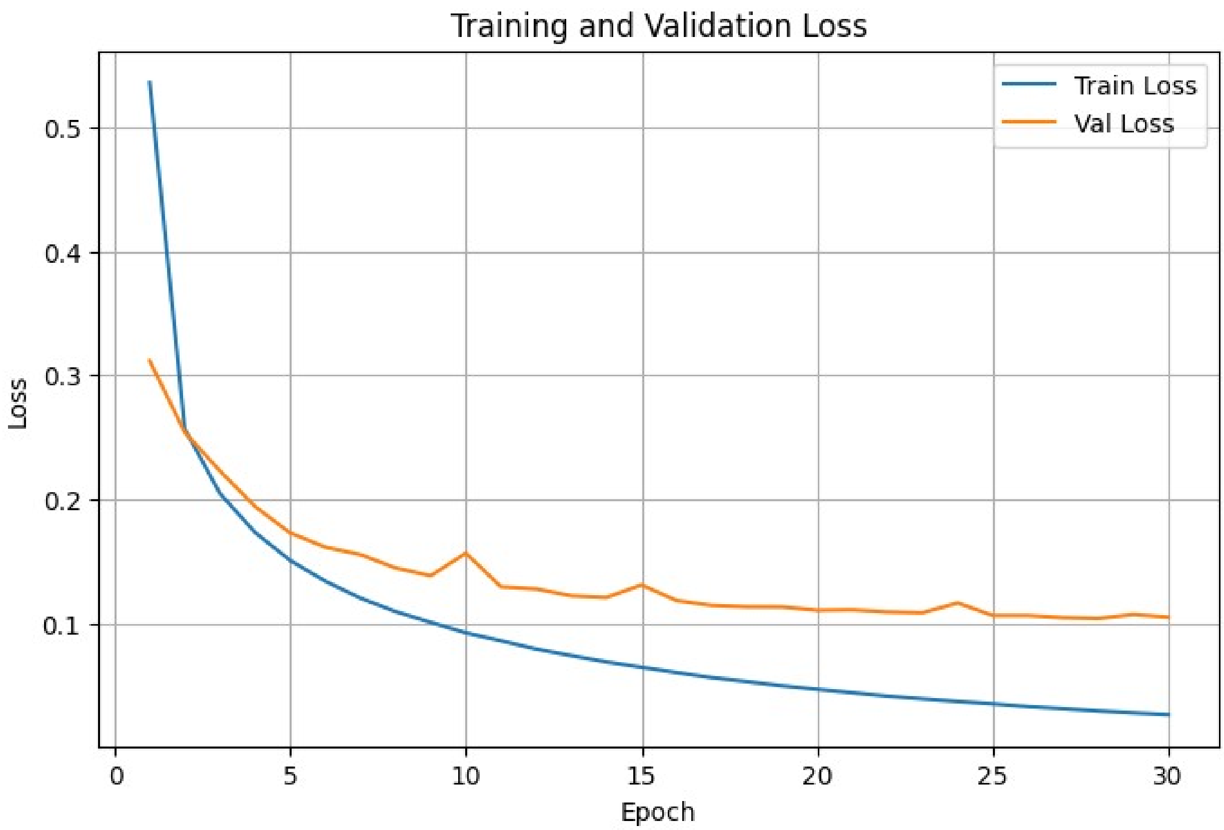
```
csv_path = os.path.join("model1", "results.csv")
results = pd.read_csv(csv_path)

results.head()
```

	epoch	train_loss	val_loss	train_acc	val_acc	train_std	val_std
0	1	0.535764	0.311580	0.840357	0.904833	0.404488	0.097451
1	2	0.256632	0.253979	0.925762	0.922444	0.091679	0.091255
2	3	0.204804	0.222912	0.941452	0.934111	0.084033	0.087833
3	4	0.173411	0.194304	0.951238	0.943167	0.077791	0.086038
4	5	0.150891	0.172998	0.957000	0.948222	0.069916	0.079991

4 Plot Training and Validation Loss over Epochs

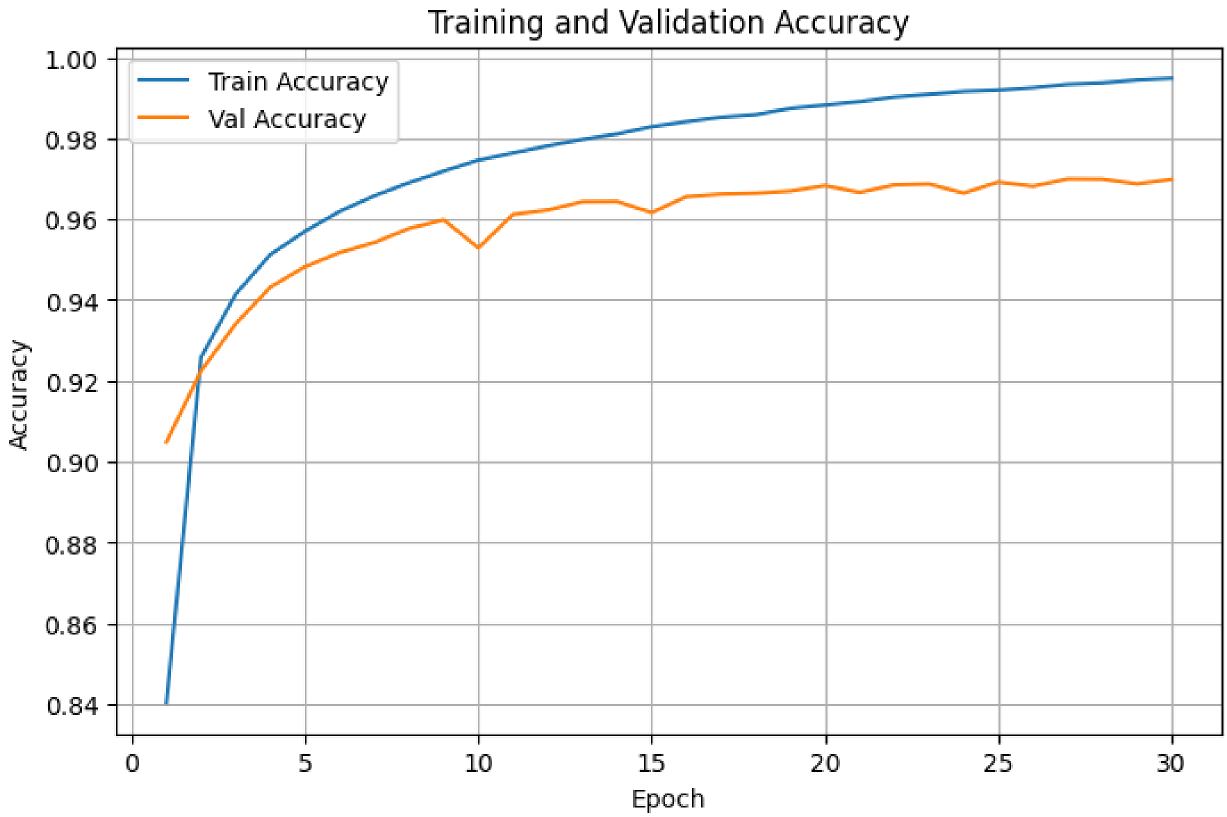
```
plt.figure(figsize=(8,5))
plt.plot(results["epoch"], results["train_loss"], label="Train Loss")
plt.plot(results["epoch"], results["val_loss"], label="Val Loss")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Training and Validation Loss")
plt.legend()
```

```
plt.grid(True)
plt.show()
```



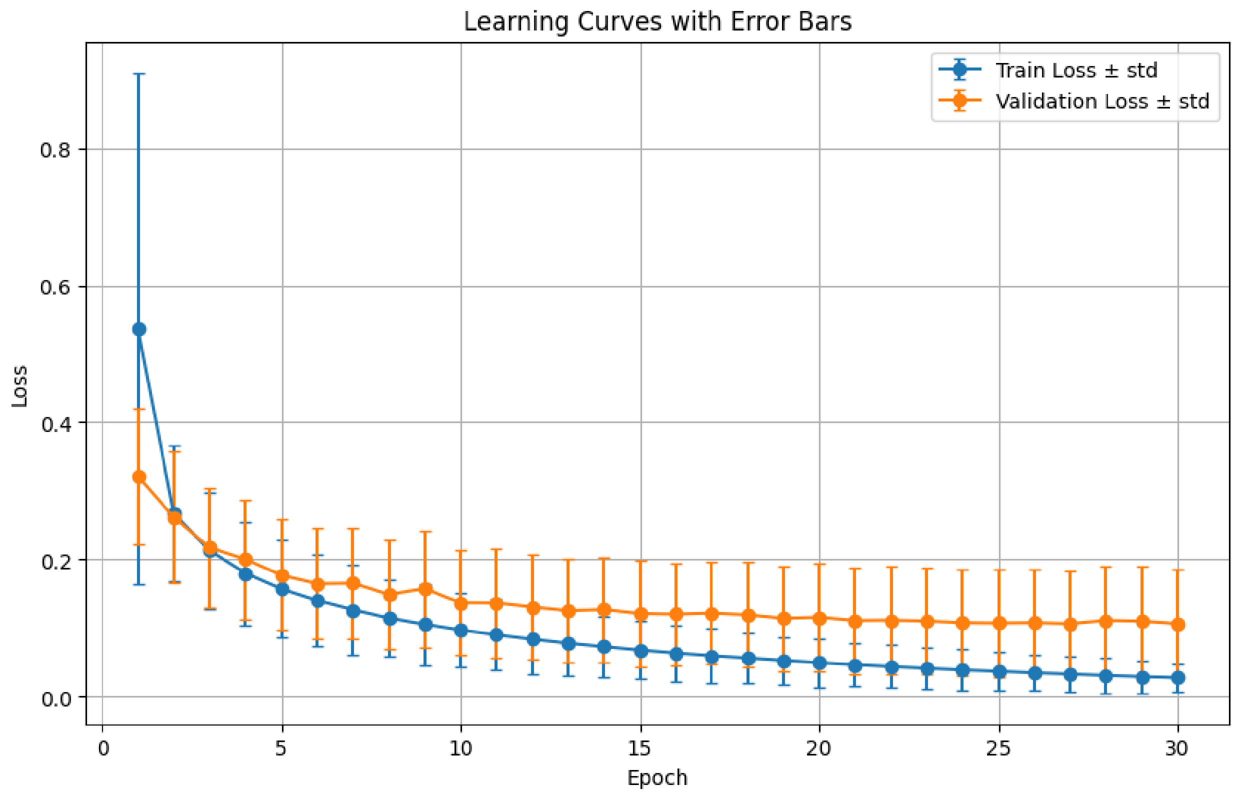
5 Plot Training and Validation Accuracy over Epochs

```
plt.figure(figsize=(8,5))
plt.plot(results["epoch"], results["train_acc"], label="Train
Accuracy")
plt.plot(results["epoch"], results["val_acc"], label="Val Accuracy")
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Training and Validation Accuracy")
plt.legend()
plt.grid(True)
plt.show()
```



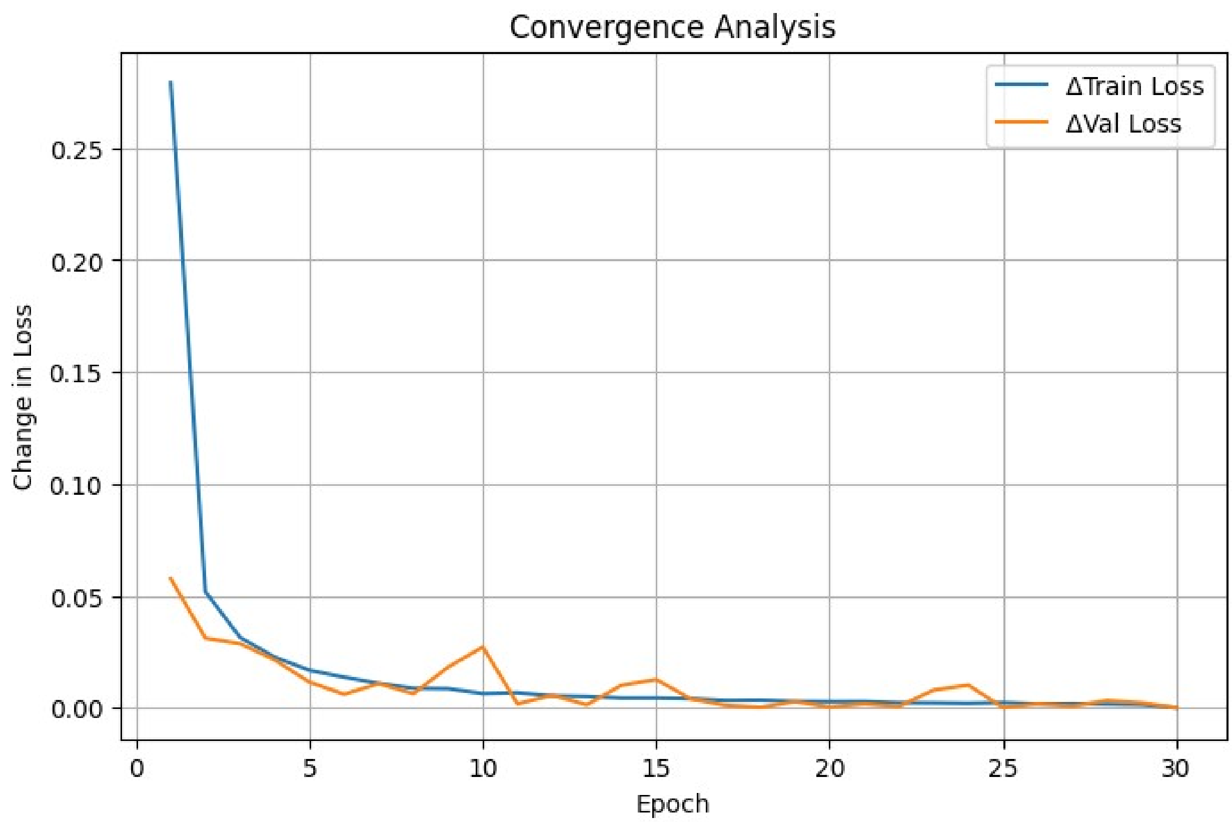
6 Learning curves with error bars

```
epochs = results['epoch']
train_loss = results['train_loss']
val_loss = results['val_loss']
train_std = results['train_std']
val_std = results['val_std']

plt.figure(figsize=(10,6))
plt.errorbar(epochs, train_loss, yerr=train_std, label="Train Loss ±
std", fmt='-o', capsize=3)
plt.errorbar(epochs, val_loss, yerr=val_std, label="Validation Loss ±
std", fmt='-o', capsize=3)
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Learning Curves with Error Bars")
plt.legend()
plt.grid(True)
plt.show()
```



7 Convergence Analysis

```
epochs = results['epoch']
train_loss = results['train_loss']
val_loss = results['val_loss']

plt.figure(figsize=(8,5))
plt.plot(epochs, np.abs(np.diff([*train_loss, train_loss.iloc[-1]])),
label="ΔTrain Loss")
plt.plot(epochs, np.abs(np.diff([*val_loss, val_loss.iloc[-1]])),
label="ΔVal Loss")
plt.xlabel("Epoch")
plt.ylabel("Change in Loss")
plt.title("Convergence Analysis")
plt.legend()
plt.grid(True)
plt.show()
```



8 Model Evaluation

Load best model

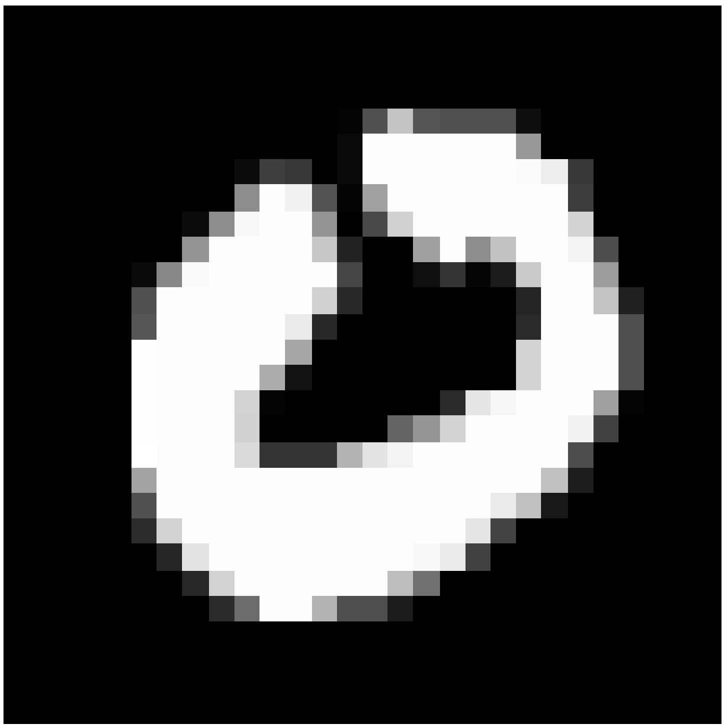
```
best_model = CustomNeuralNet(
    sizes=[28*28, 128, 64, 10],
    activation=nn.ReLU,
    weight_init="he"
)

path = os.path.join("model1", "weights", "best.pt")
checkpoint = torch.load(path, map_location=device)
best_model.load_state_dict(checkpoint['model_state'])
best_model.to(device)
best_model.eval()
```

Predict on a single test image

```
# Pick a single test image
idx = 25
x_sample = X_test[idx].unsqueeze(0)  # shape [1, 784]
y_true = y_test[idx].item()

# Make prediction
with torch.no_grad():
```

```
    outputs = best_model(x_sample)
    _, pred = torch.max(outputs, 1)

# Display image and prediction
plt.imshow(X_test[idx].view(28, 28).cpu(), cmap="gray")
plt.title(f"True: {y_true} | Predicted: {pred.item()}")
plt.axis("off")
plt.show()
```

True: 0 | Predicted: 0



Evaluate accuracy on the full test set

```
correct = 0
total = 0

best_model.eval()
with torch.no_grad():
    outputs = best_model(X_test.to(device))
    _, predicted = torch.max(outputs, 1)
    correct = (predicted == y_test).sum().item()
    total = y_test.size(0)

test_acc = correct / total
print(f"Test Accuracy: {test_acc:.4f}")
```

```
Test Accuracy: 0.9723
```