

Neural Evolution for Handwritten Digit Recognition using Differential Evolution (DE)

Introduction

Objective:

- Explore and optimize NN weights using Differential Evolution (DE) and gradient descent (MLP) to find best solutions with minimum error rate
- Analyze performance metrics and convergence trends.

Key Deliverables:

- Dashboard/UI for performance visualization.
- Learning curves to track progress.
- Methodology .

References

<https://medium.com/@mandarangchekar7/neural-network-optimization-part-1-differential-evolution-algorithm-c5e2188b6283>

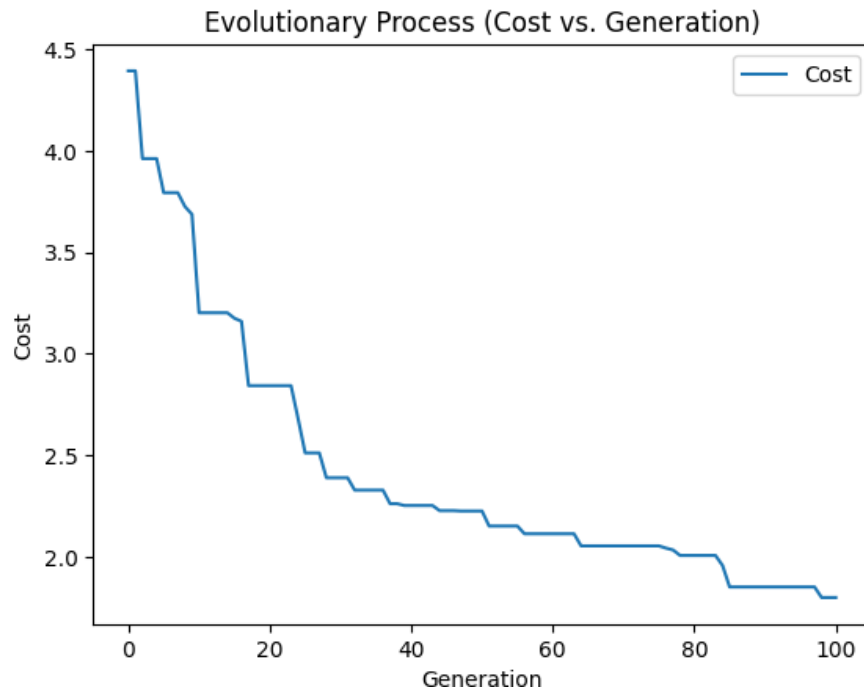
<https://www.mdpi.com/2227-7390/8/1/69>

Learning curves to track progress

Real-time visualization of fitness trends over generations (3 different curves examples .):

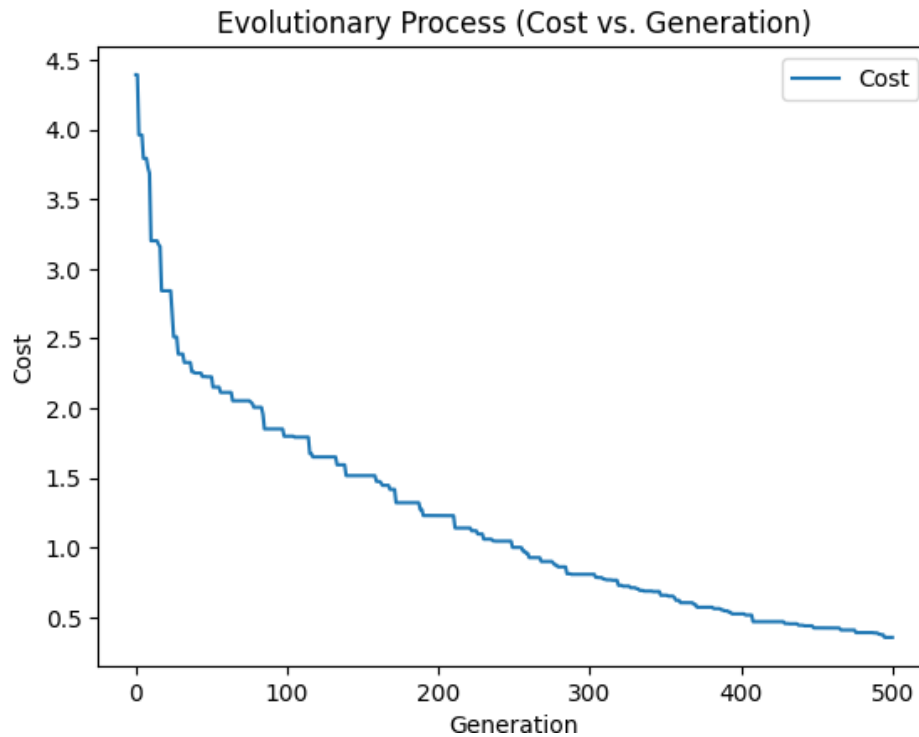
First 100 generations:

Generation 100, Cost: 1.7985



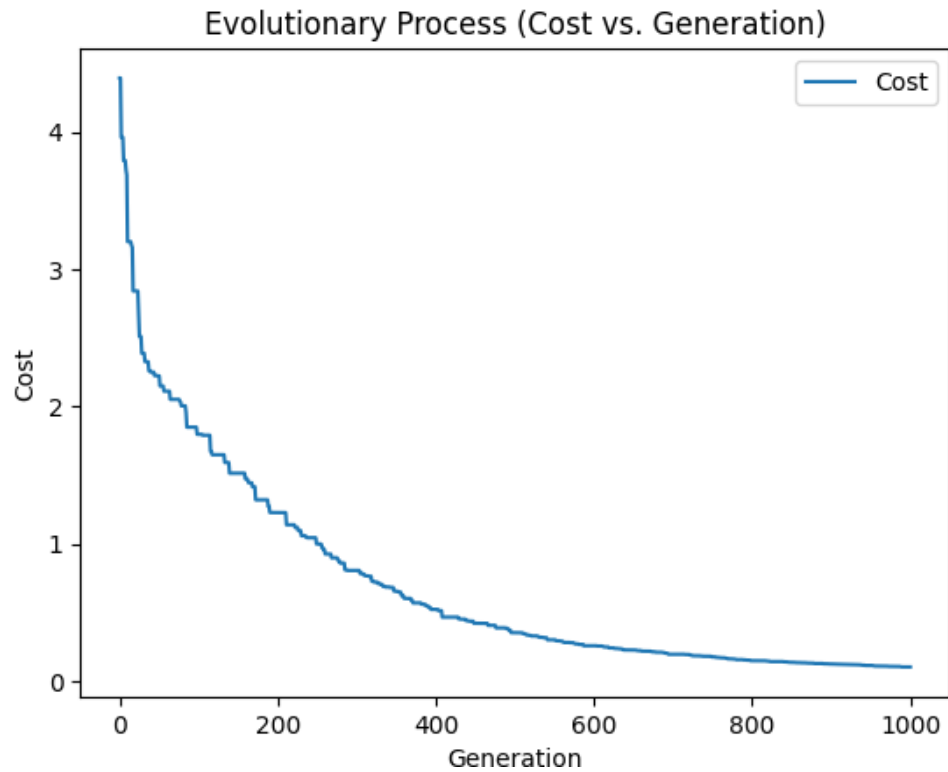
**100
generations
from the
middle of
evolution:**

Generation 500, Cost: 0.3546

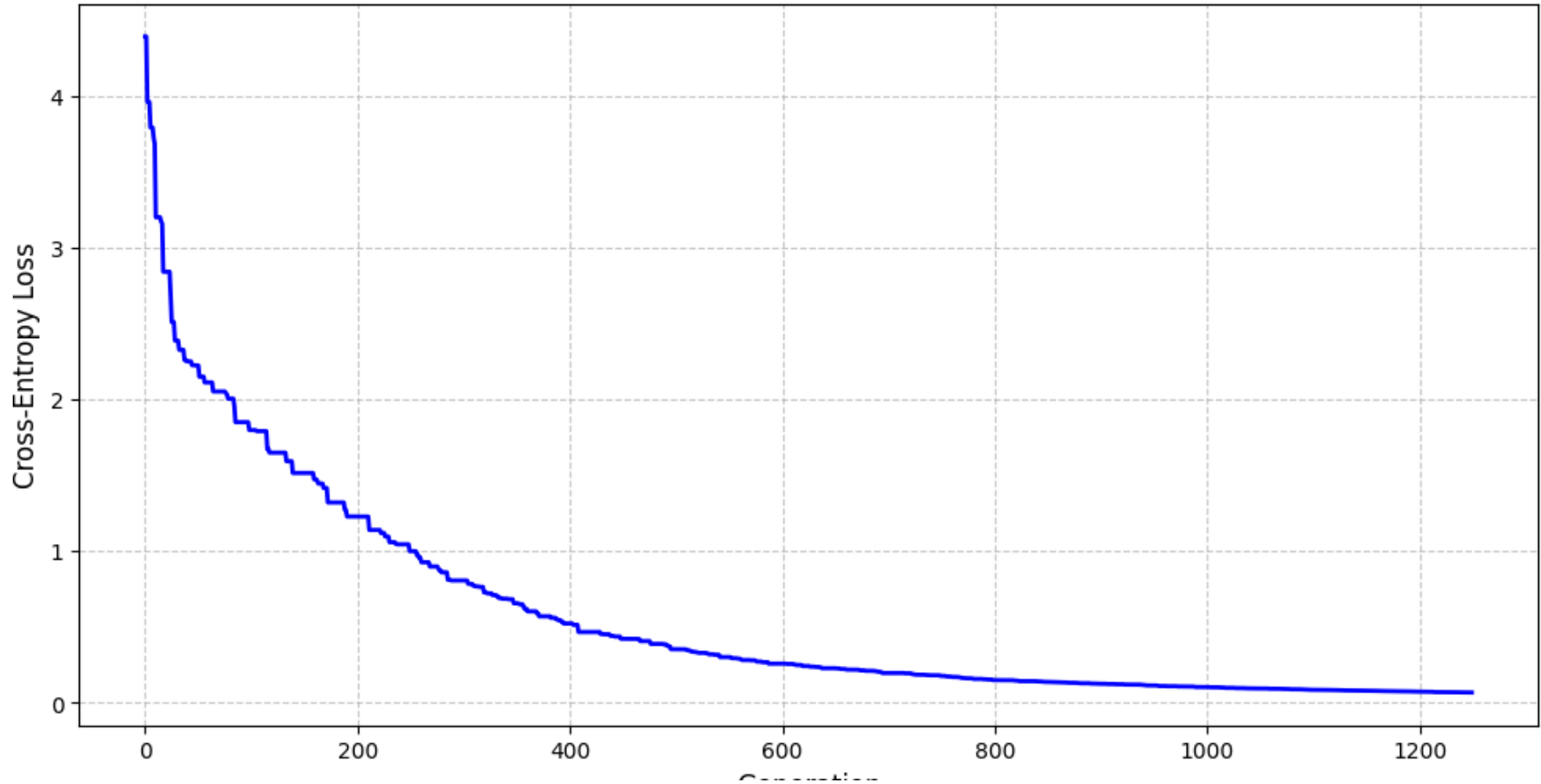


**Till 1000
generations :**

Generation 1000, Cost: 0.1047



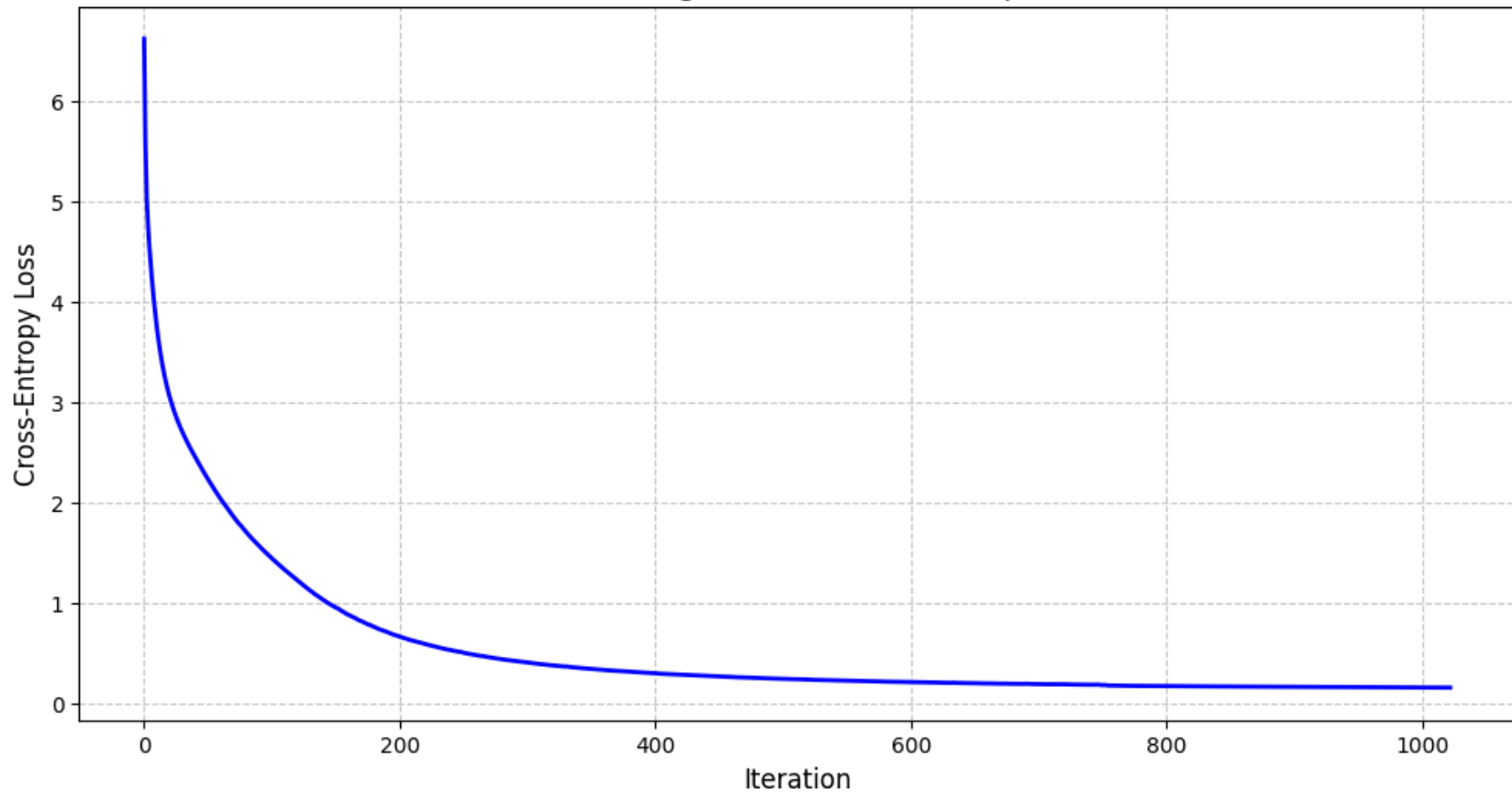
Loss Curve During Differential Evolution Optimization



Final Evolution using Differential Evolution (DE)

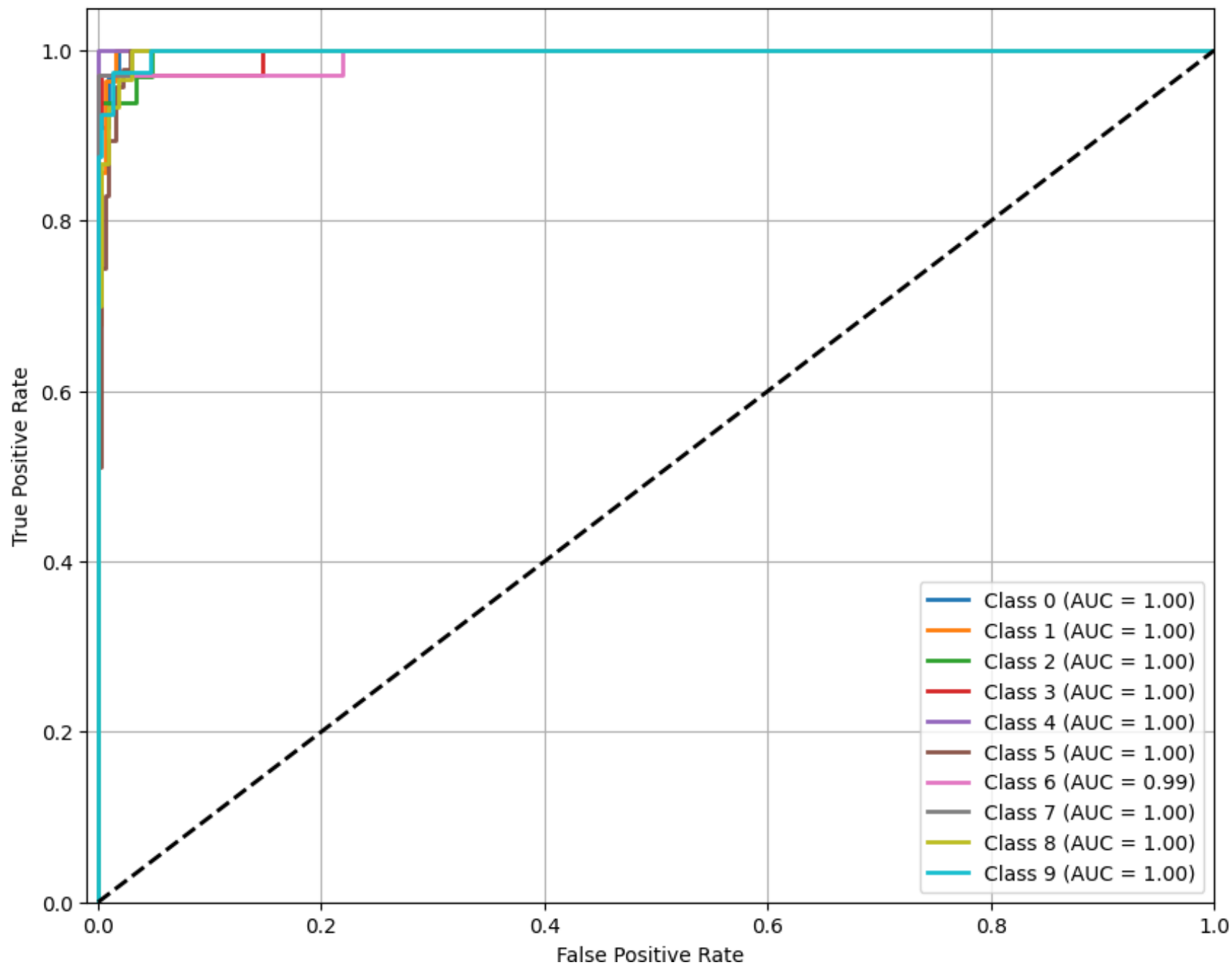
Accuracy: 95.83

Loss Curve During Gradient Descent Optimization

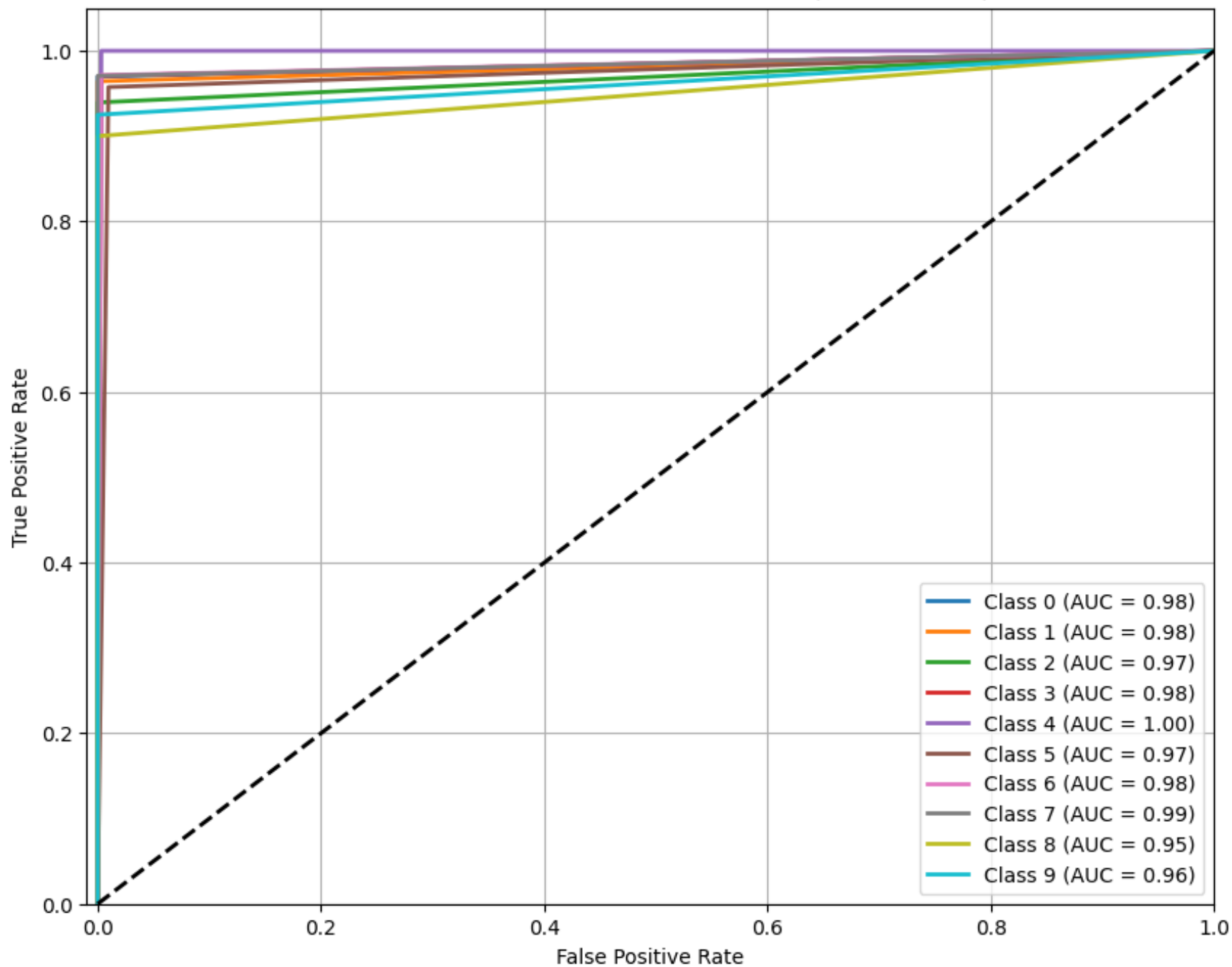


Final training after using gradient descent (MLP)

Multiclass ROC Curve - Differential Evolution



Multiclass ROC Curve - Gradient Descent (MLPClassifier)



Methodology

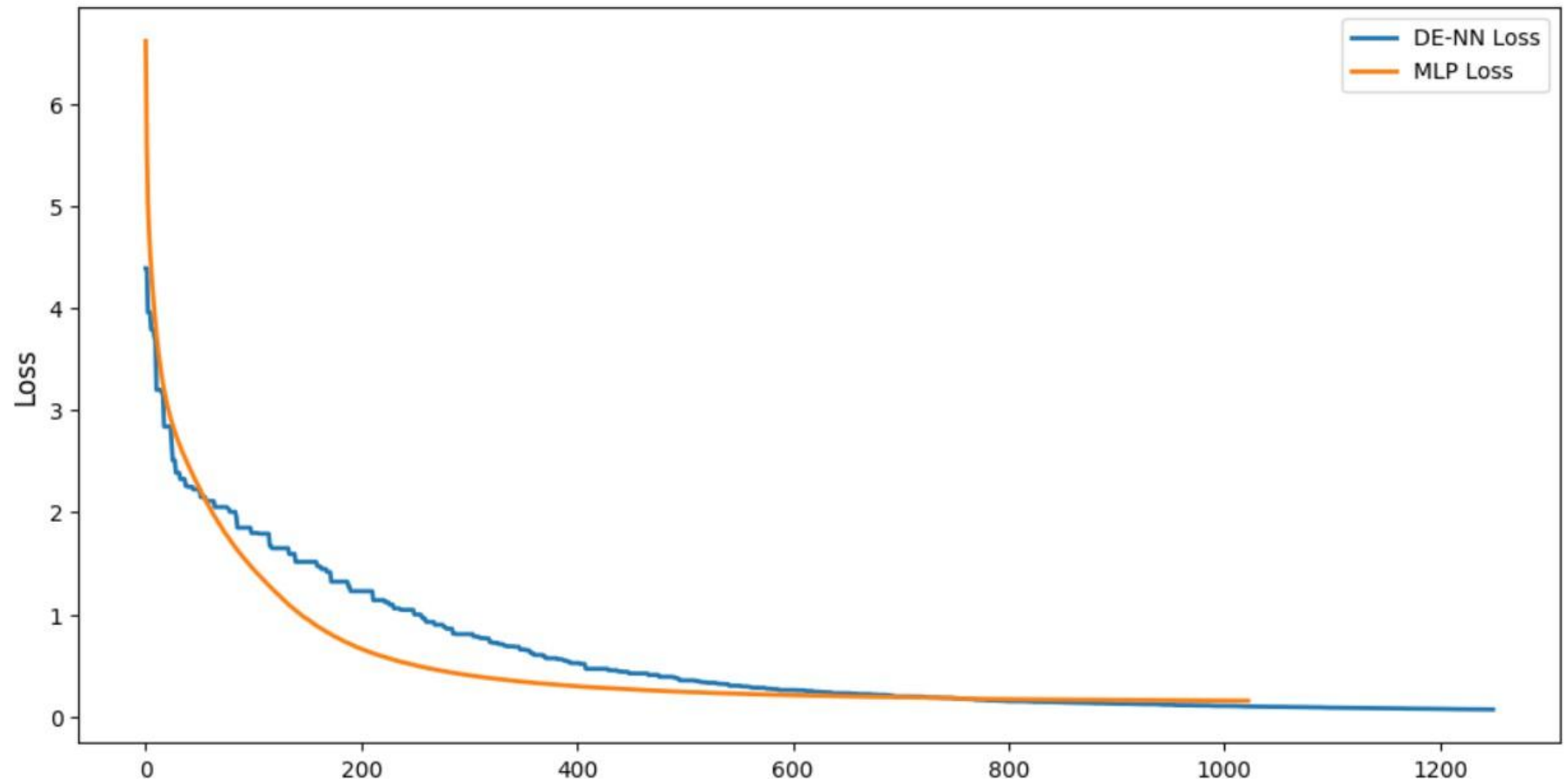
Classification Report for **DE**

	precision	recall	f1-score	support
0	0.91	0.91	0.91	33.00
1	0.93	0.93	0.93	28.00
2	1.00	0.94	0.97	33.00
3	0.94	0.97	0.96	34.00
4	1.00	0.98	0.99	46.00
5	0.88	0.96	0.92	47.00
6	0.97	0.97	0.97	35.00
7	1.00	0.97	0.99	34.00
8	0.88	0.93	0.90	30.00
9	0.97	0.90	0.94	40.00
accuracy	0.95	0.95	0.95	0.95
macro avg	0.95	0.95	0.95	360.00
weighted avg	0.95	0.95	0.95	360.00

Classification Report for **MLP**

	precision	recall	f1-score	support
0	0.78	0.97	0.86	33.00
1	1.00	0.96	0.98	28.00
2	1.00	0.94	0.97	33.00
3	0.97	0.97	0.97	34.00
4	0.98	1.00	0.99	46.00
5	0.94	0.96	0.95	47.00
6	0.97	0.97	0.97	35.00
7	1.00	0.97	0.99	34.00
8	1.00	0.90	0.95	30.00
9	1.00	0.92	0.96	40.00
accuracy	0.96	0.96	0.96	0.96
macro avg	0.96	0.96	0.96	360.00
weighted avg	0.96	0.96	0.96	360.00

Iteration / Generation Loss curves



Aspect	DE-NN (Differential Evolution)	MLPClassifier (Gradient-based)	Which is Better?
Accuracy	94.72%	95.83%	MLP
Macro F1-score	0.95	0.96	MLP
Weighted F1-score	0.95	0.96	MLP
Training Time	271.70 seconds	24.20 seconds	MLP
Loss Curve	Stepped, slow convergence	Smooth, fast convergence	MLP
Optimization Method	Evolutionary (Population-based)	Gradient-based (Backpropagation)	Depends on task
Overall Verdict	MLPClassifier is better for this classification task due to higher accuracy, faster training time, and smoother convergence. DE-NN is still useful when gradients are unavailable or you need black-box optimization.		

Thank You