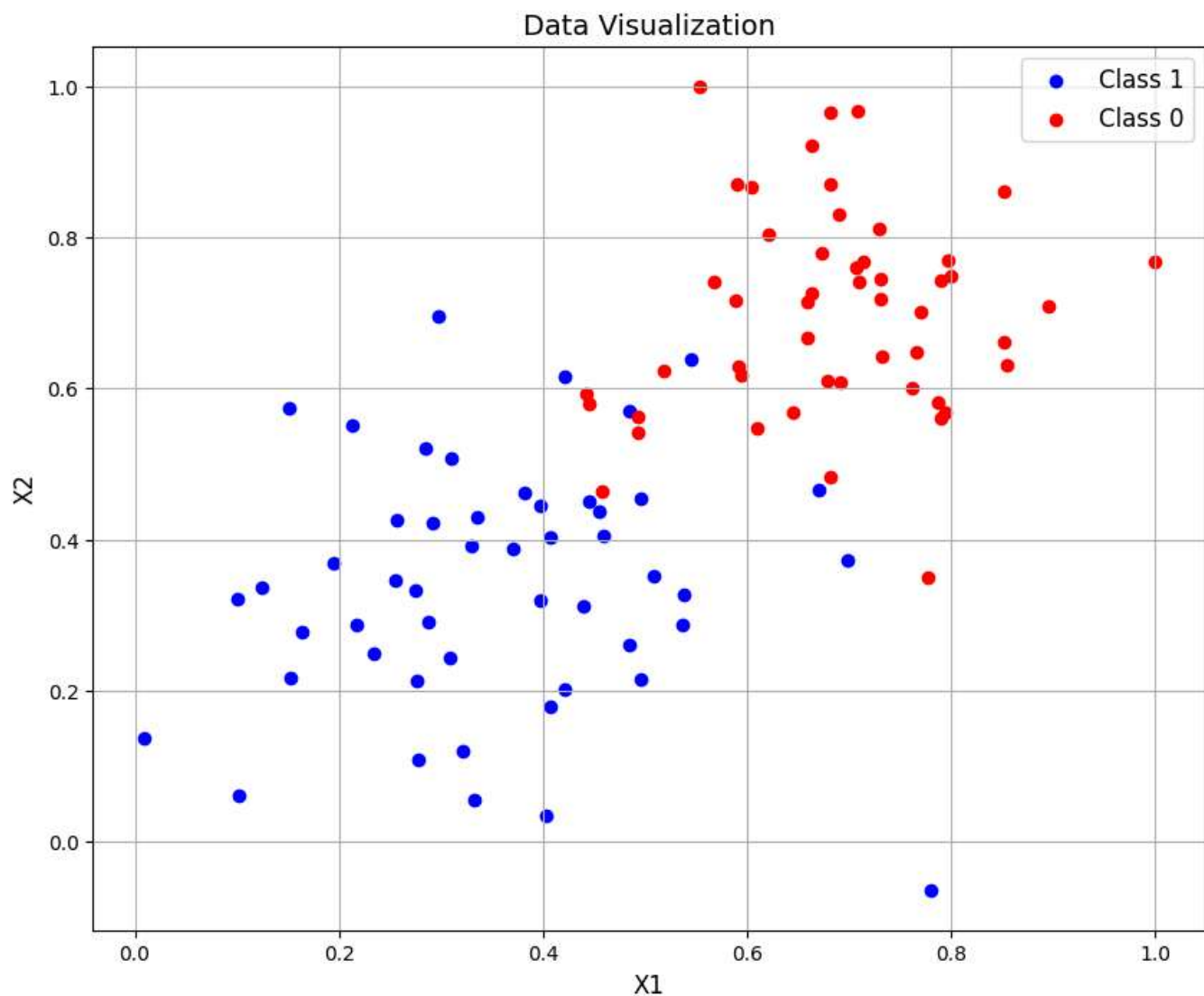


Assignment#4: Perceptron

Data Loading and Exploration

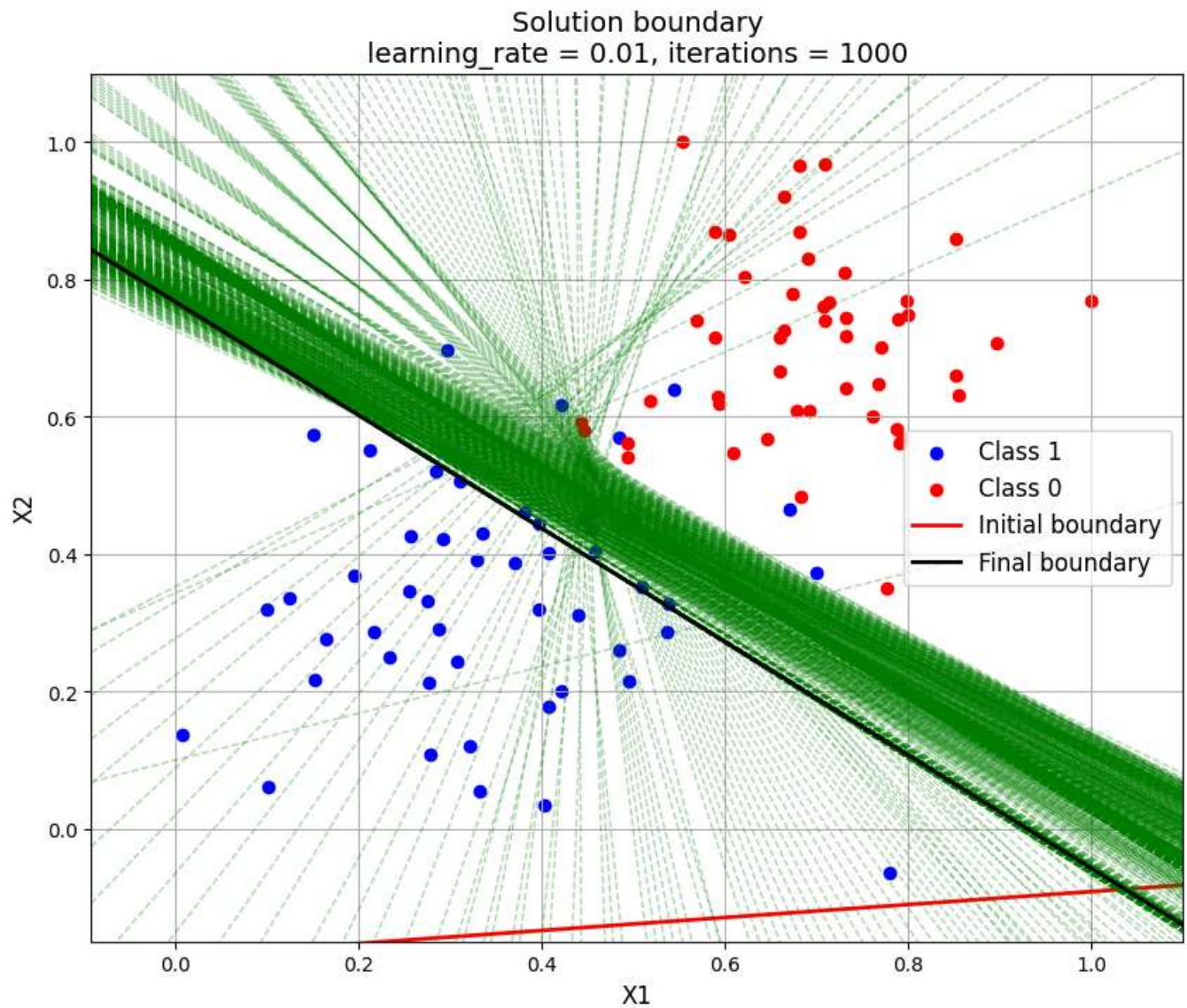
Data shape: (100, 3)

	X1	X2	y
0	0.78051	-0.063669	1
1	0.28774	0.291390	1
2	0.40714	0.178780	1
3	0.29230	0.421700	1
4	0.50922	0.352560	1

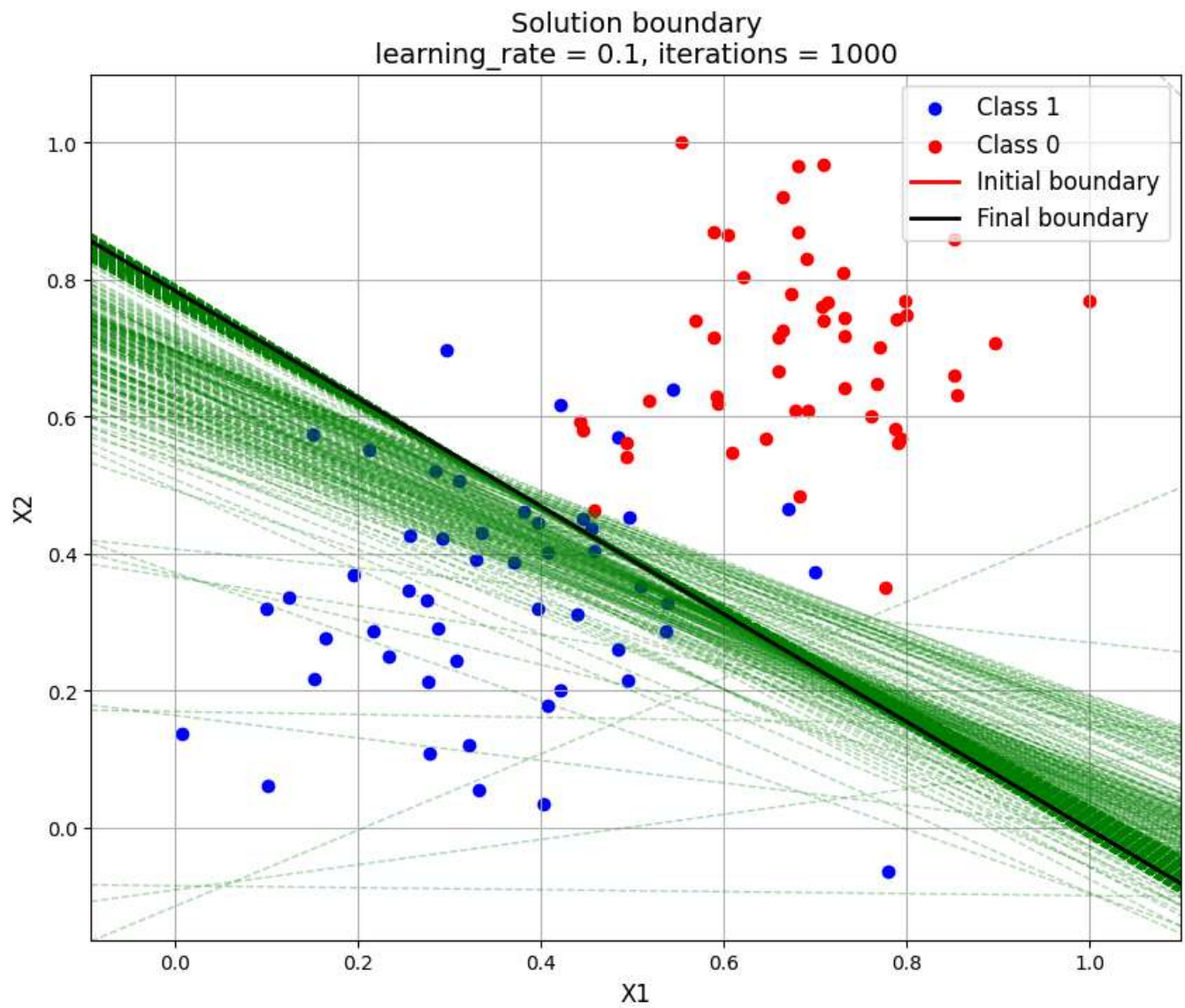


Part 1: Perceptron with Heuristic Approach

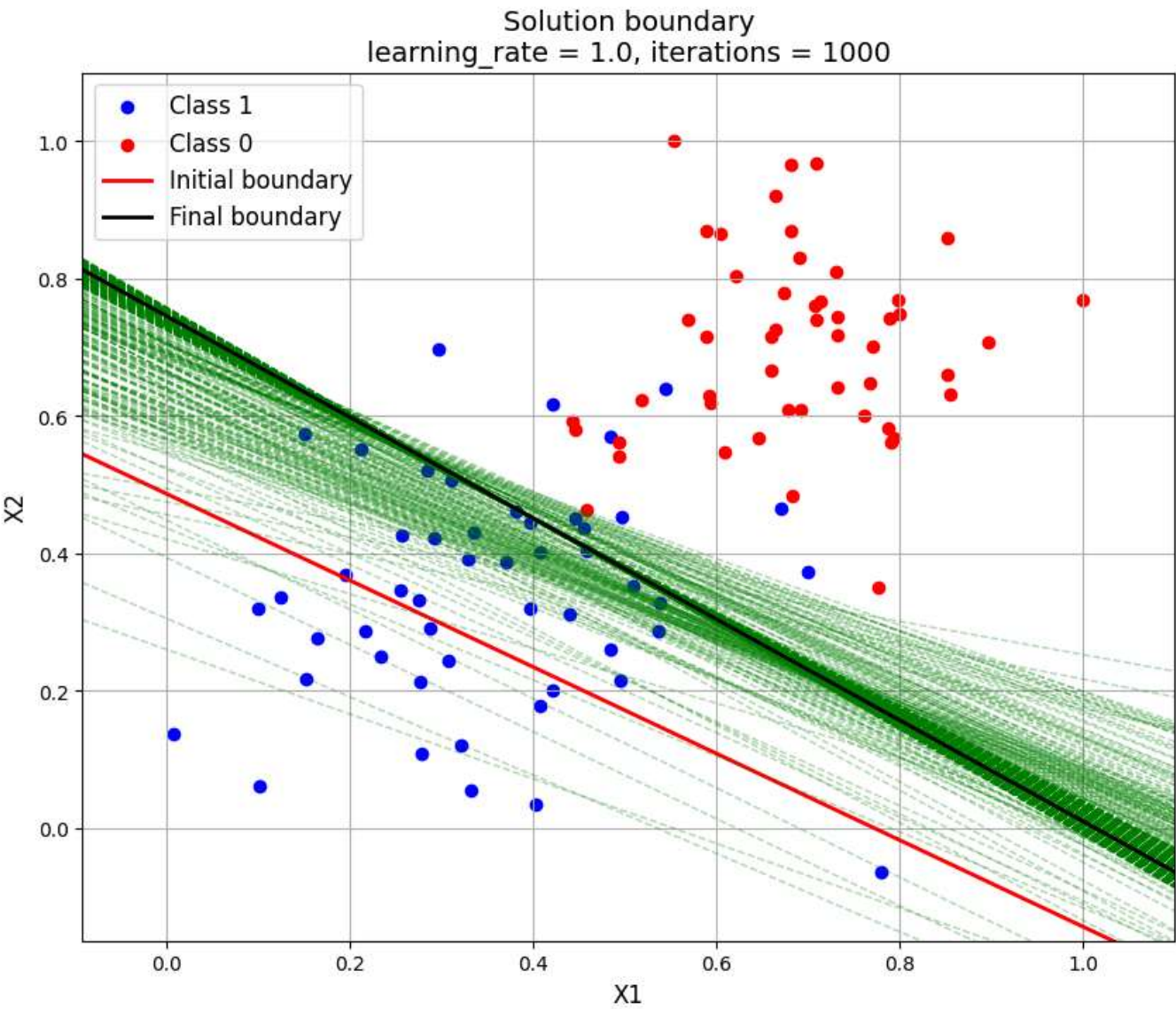
Plot: Part 1 - Heuristic Approach with learning_rate = 0.01



Plot: Part 1 - Heuristic Approach with learning_rate = 0.1



Plot: Part 1 - Heuristic Approach with learning_rate = 1.0

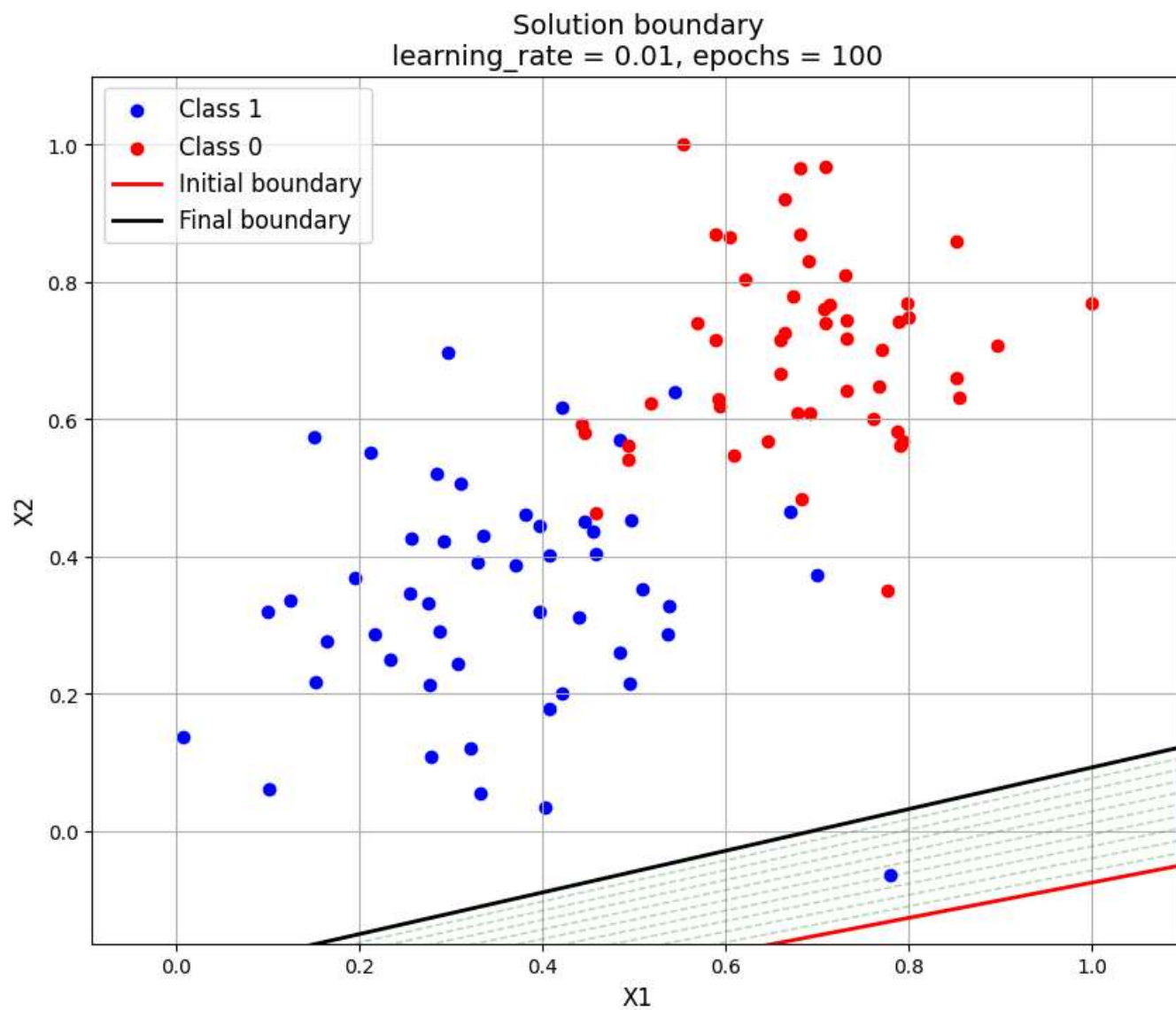


Part 1 Results:

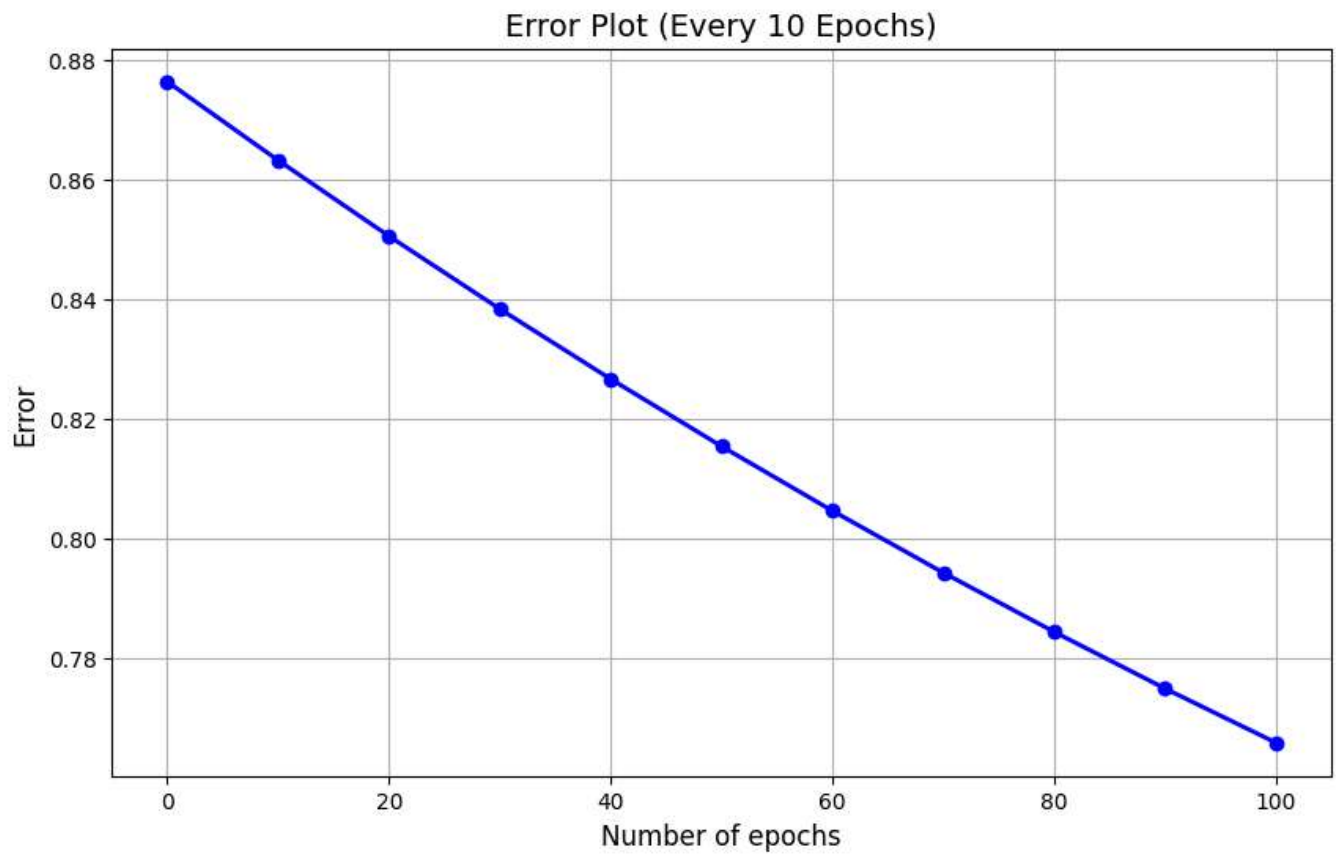
	learning_rate	iterations	final_weights	final_bias
0	0.01	1000	<code>[-0.13684938476419767, -0.16581163537433544]</code>	0.127341
1	0.10	1000	<code>[-0.8739147408902393, -1.110438222908007]</code>	0.870871
2	1.00	1000	<code>[-7.8659531675637835, -10.690256995798238]</code>	7.974875

Part 2: Perceptron with Gradient Descent Approach

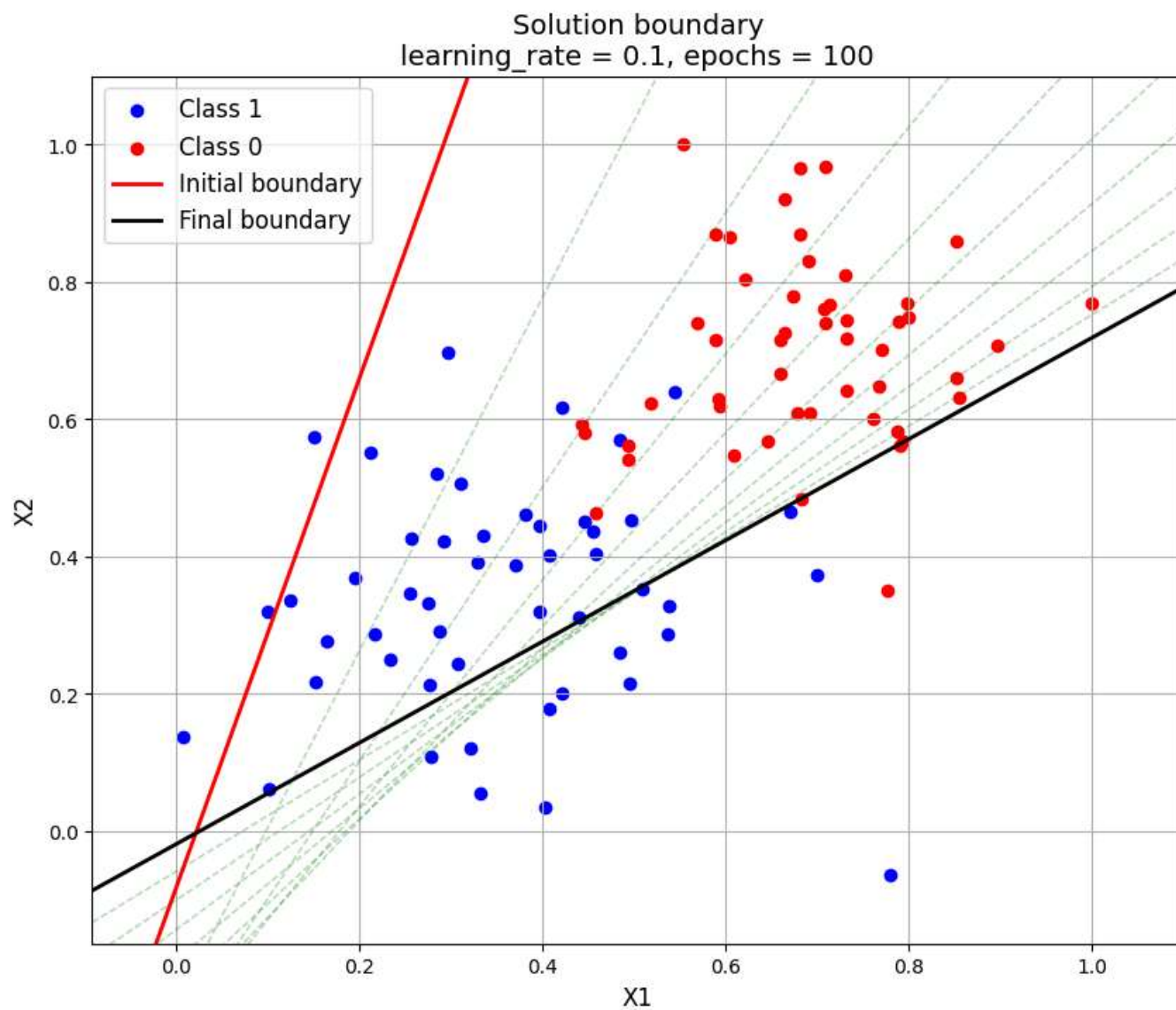
Plot: Part 2 - Decision Boundary with learning_rate = 0.01, epochs = 100



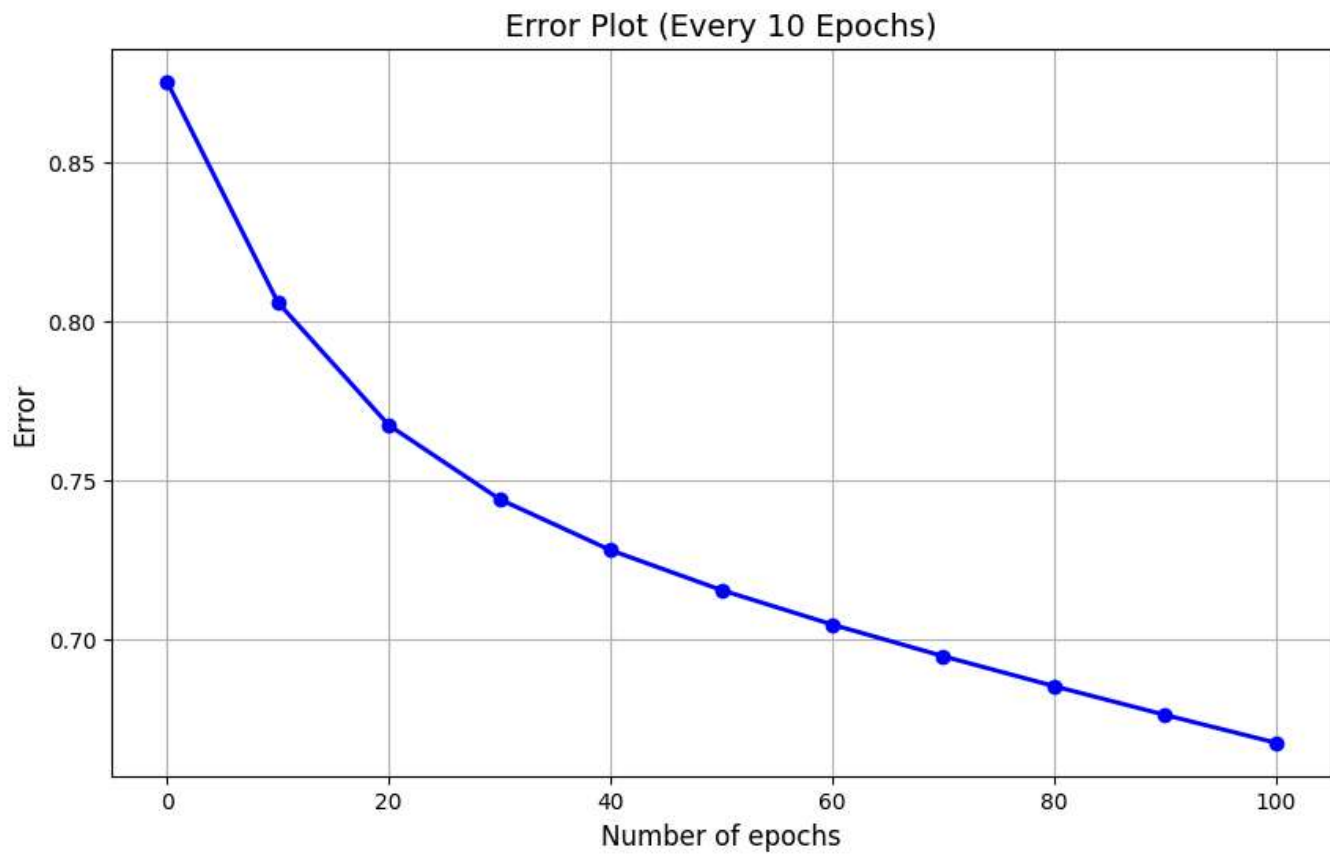
Plot: Part 2 - Error Plot with learning_rate = 0.01, epochs = 100



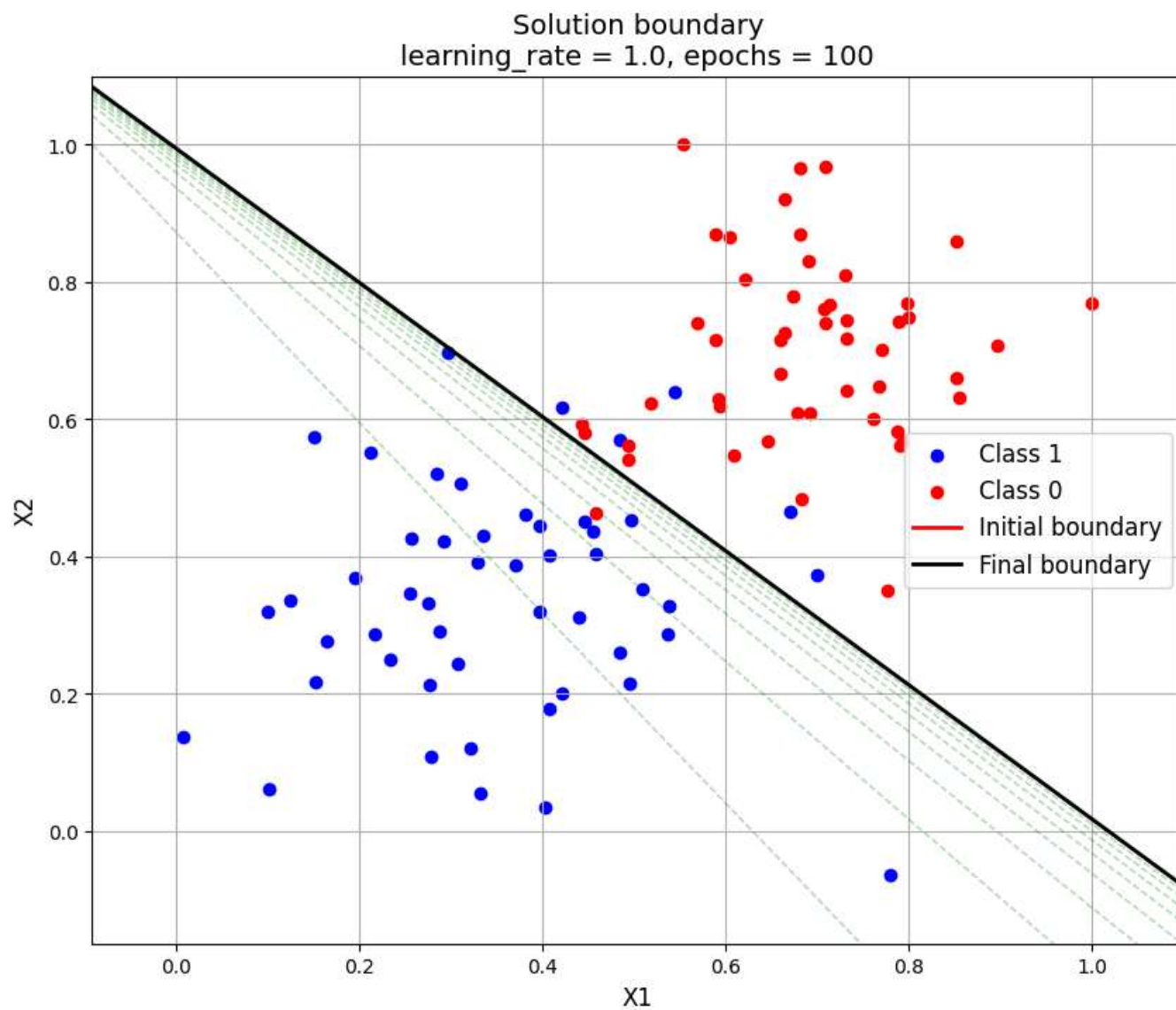
Plot: Part 2 - Decision Boundary with learning_rate = 0.1, epochs = 100



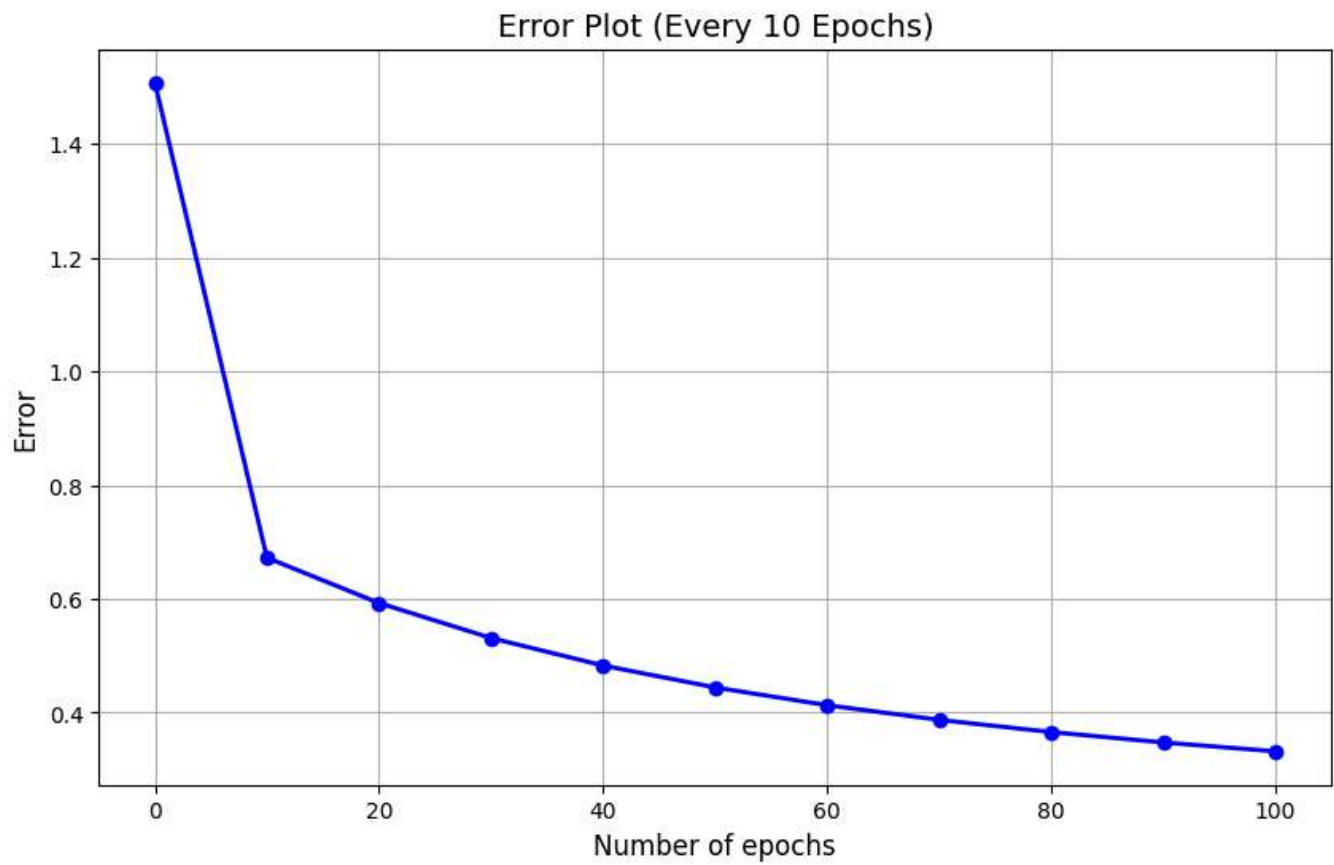
Plot: Part 2 - Error Plot with learning_rate = 0.1, epochs = 100



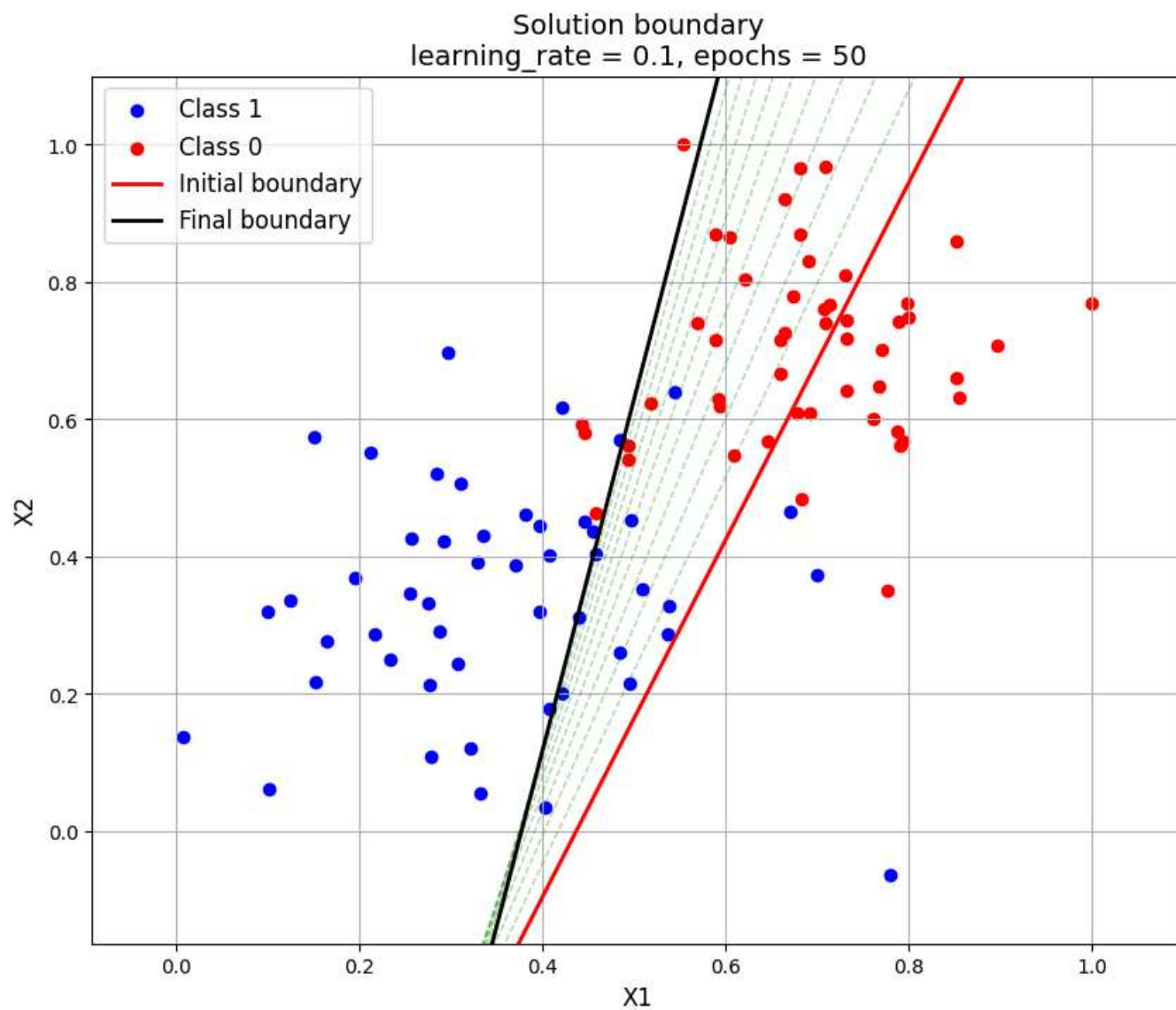
Plot: Part 2 - Decision Boundary with learning_rate = 1.0, epochs = 100



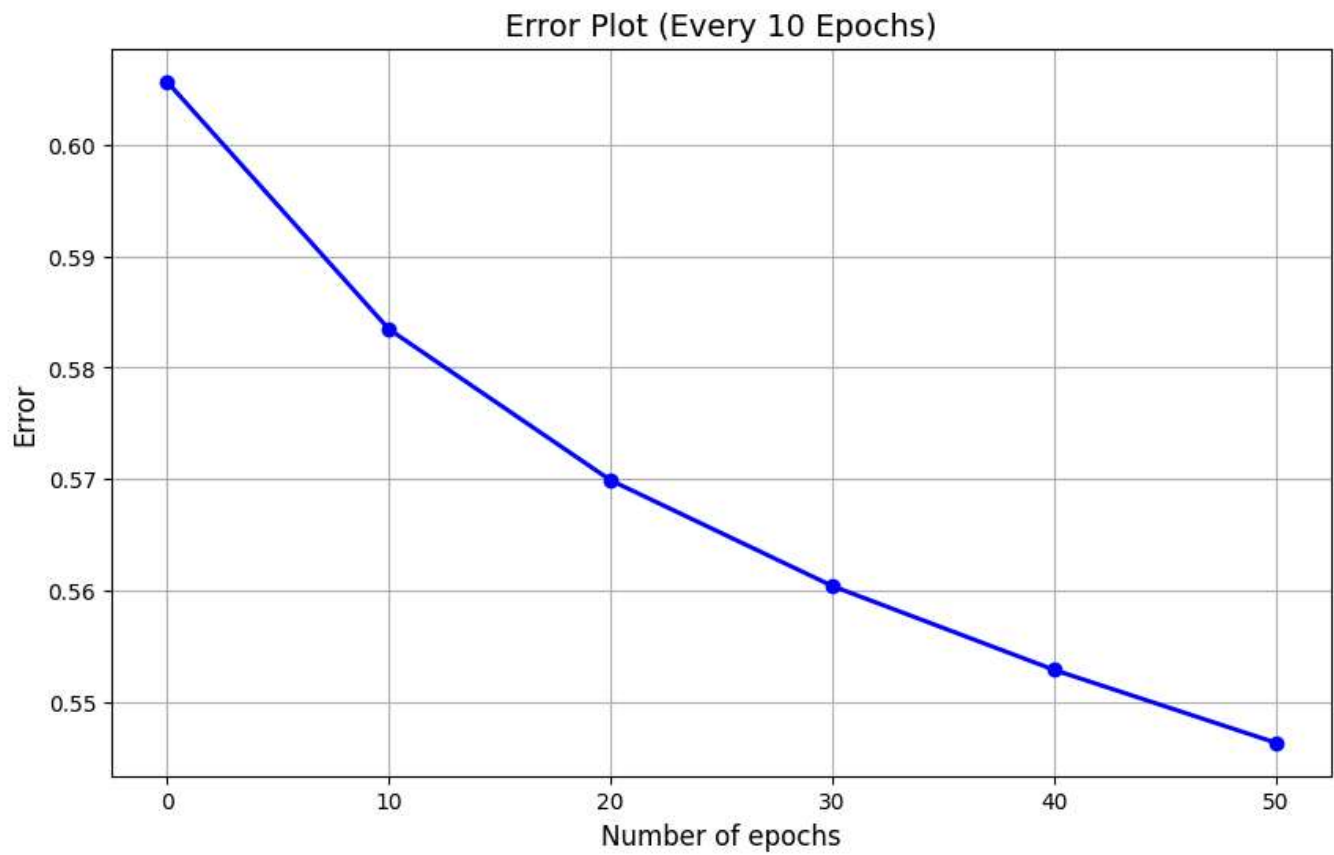
Plot: Part 2 - Error Plot with learning_rate = 1.0, epochs = 100



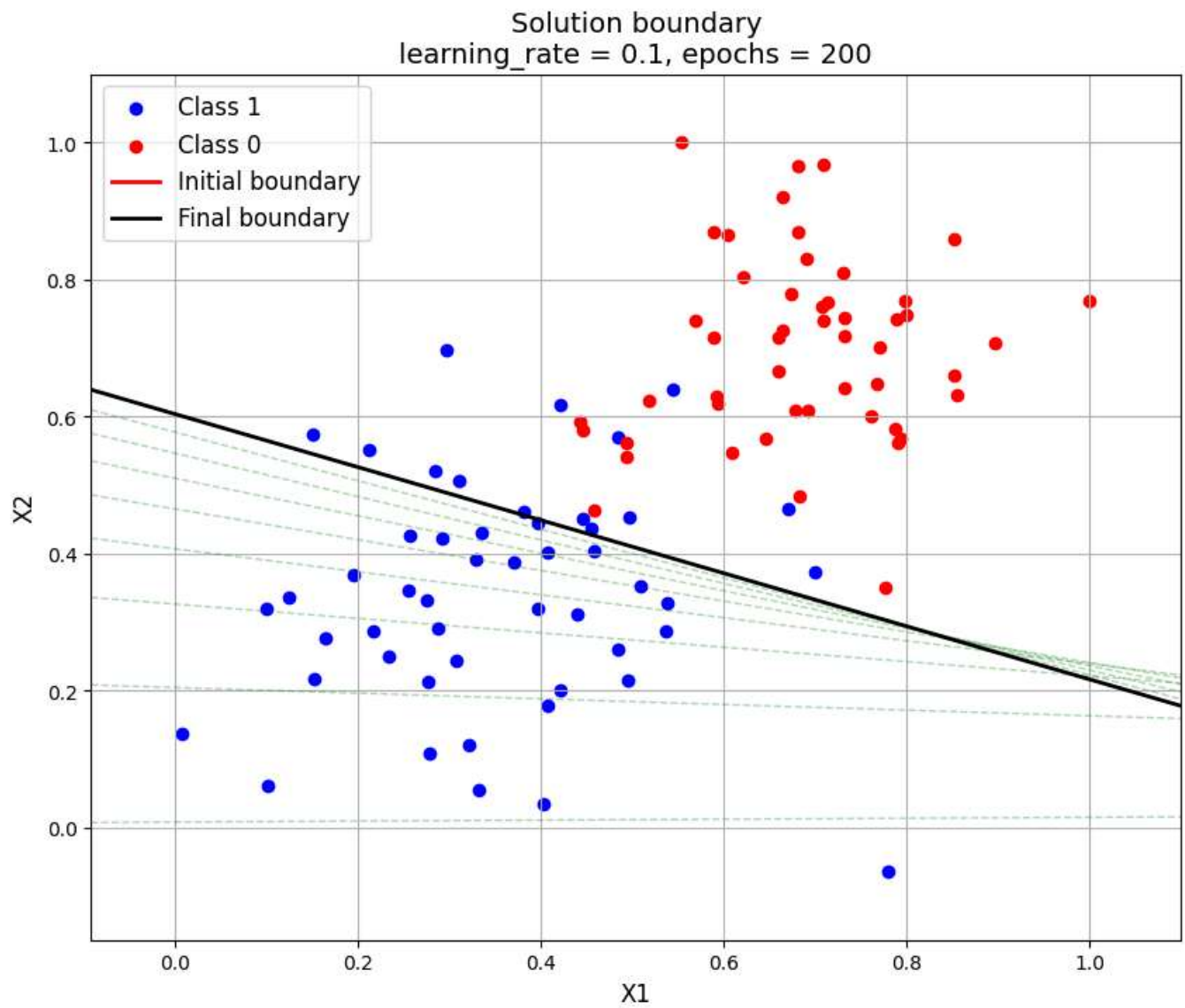
Plot: Part 2 - Decision Boundary with learning_rate = 0.1, epochs = 50



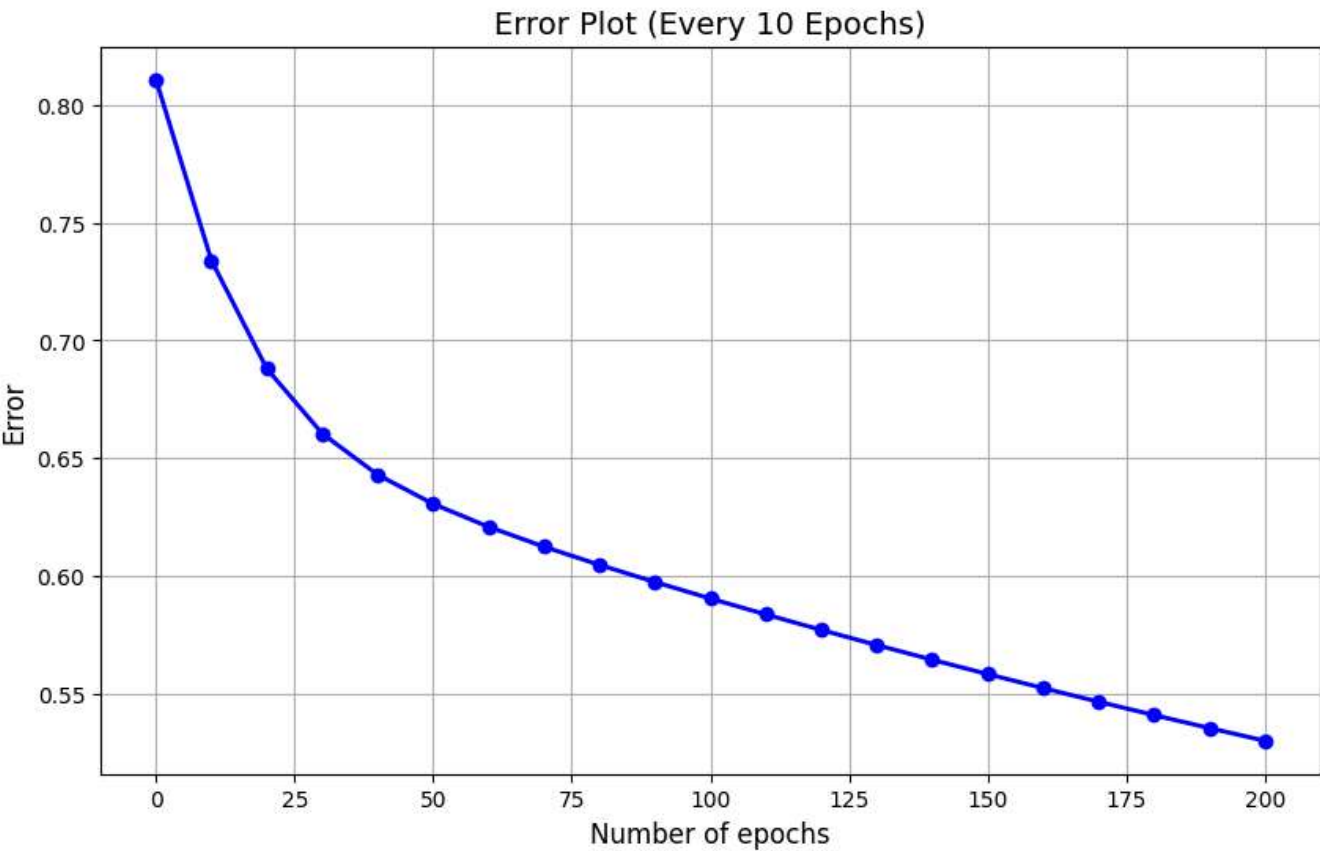
Plot: Part 2 - Error Plot with learning_rate = 0.1, epochs = 50



Plot: Part 2 - Decision Boundary with learning_rate = 0.1, epochs = 200



Plot: Part 2 - Error Plot with learning_rate = 0.1, epochs = 200



Part 2 Results:

	learning_rate	epochs	final_weights	final_bias	final_loss
0	0.01	100	[0.7005462847183637, -2.306868797767225]	-0.486227	0.765859
1	0.10	100	[1.0116298691218166, -1.370870732345595]	-0.026189	0.667187
2	1.00	100	[-3.1369932715979116, -3.209433534781439]	3.193585	0.332196
3	0.10	50	[-2.810725192078327, 0.5488417835524867]	1.060486	0.546332
4	0.10	200	[-0.6168204014131361, -1.5921856268841403]	0.961818	0.530200

Analysis of Part 1:

In Part 1, the perceptron model effectively distinguishes two classes, with the error consistently decreasing as epochs increase, demonstrating clear convergence. Comparing learning rates (0.01, 0.1, 1.0) reveals that higher learning rates accelerate convergence significantly, achieving a low final error (~0.4 for learning rate 1.0 compared to ~0.7 for learning rate 0.01). Boundaries evolve rapidly from initial to final positions, especially at the highest learning rate (1.0), which results in the most distinct and accurate classification boundary.

Analysis of Part 2:

In Part 2, varying epochs (50, 100, 200) and learning rates (0.01, 0.1, 1.0) highlights important differences in convergence behavior. Increasing epochs consistently improves accuracy, with the error significantly reduced at 200 epochs (~ 0.55) compared to 50 epochs (~ 0.60). The solution boundaries become progressively more accurate with increasing epochs. High learning rates (0.1 and 1.0) again demonstrate more rapid convergence and clearer class separability compared to the slower learning rate of 0.01. Optimal classification boundaries and minimal error are clearly achieved at higher learning rates and higher epoch counts.