Assignment: Few-Shot Classification with MAML

Deadline - Sunday 8 Feb 2026

1 Problem Statement

1.1 The "Moving Circle" Dataset

You will generate a synthetic 2D dataset where the decision boundary is a circle. The underlying "concept" (a circular region) remains constant, but the specific location of the circle shifts for every task.

- **Input Space:** $x \in \mathbb{R}^2$ where $x_1, x_2 \in [-5, 5]$.
- **Task Distribution $p(\mathcal{T})$:** For each task $\mathcal{T}_i$, generate a circle with a fixed radius $r = 2.0$ and a random center (c_x, c_y) sampled uniformly from $[-3, 3]$.
- **Labels:**

$$y = \begin{cases} 1 & \text{if } \sqrt{(x_1 - c_x)^2 + (x_2 - c_y)^2} < r \\ 0 & \text{otherwise} \end{cases}$$

1.2 The Goal

Train a neural network f_θ that can learn the decision boundary of a **new, unseen circle** using only **K=10** labeled examples (Support Set) and just **1 gradient update**.

2 Methodology

2.1 Part 1: MAML Implementation

Implement the MAML algorithm as described in Finn et al. (2017).

- **Model Architecture:** Of your Choice.
- **Meta-Training:**
  - **Outer Loop:** 2000 epochs.
  - **Inner Loop:** 1 gradient descent step
  - **Meta-Update:** As discussed

2.2 Part 2: Baseline Comparison (Standard Learning)

Train a baseline model to represent a non-meta-learning approach.

- **Joint Training:** Train a single network f_ϕ on data sampled from thousands of random tasks simultaneously (mixing all circles together). Train for 2000 epochs.
- **Fine-Tuning:** At test time, take this pre-trained model and fine-tune it on the test task's Support Set using standard Gradient Descent.

3 Deliverables

3.1 1. Quantitative Evaluation

Generate a plot showing **Test Accuracy vs. Number of Gradient Steps** (from 0 to 10 steps) on a held-out test task.

- The plot must include two curves: one for **MAML** and one for the **Baseline**.
- **Expected Result:**What would it be ? :)

3.2 2. Qualitative Visualization

Produce a visualization of the decision boundary for a single random test task.

- **Ground Truth:** Plot the actual circle boundary (dashed line).
- **Predictions:** Generate a heatmap (contour plot) representing the model's predicted probabilities across the 2D plane after **1 gradient step**.
- Compare the MAML heatmap side-by-side with the Baseline heatmap.