Project 1

Segment Anything Model under Noisy Medical Radiology Imaging Conditions

Project Overview

Recent advances in **Segment Anything Models (SAM)** have demonstrated strong generalization across natural images, and more recently, across medical imaging domains through variants such as **MedSAM** and **SAM2**. However, the robustness of these models under **realistic noisy medical imaging conditions** remains insufficiently studied.

This project aims to **systematically evaluate the robustness, stability, and failure modes of SAM-based models on 2D medical imaging datasets under controlled noise perturbations**, simulating common acquisition artifacts encountered in clinical practice. The final objective is to produce **a high-quality benchmark study** suitable for submission to a **CVPR workshop**, followed by an extended version targeting a **Q1 journal**.

Research Objectives

The project has the following core objectives:

1. **Robustness Evaluation**
   Assess how different SAM-based models perform when medical images are corrupted by various noise and artifact types.
2. **Noise Sensitivity Analysis**
   Quantify segmentation degradation under increasing noise levels and identify noise types that most significantly impact performance.
3. **Model Comparison**
   Benchmark and compare:
   - Original **SAM**
   - **SAM2**
   - Medical-domain adaptations (e.g., **MedSAM**, and other public variants)
4. **Visualization and Interpretability**
   Provide qualitative visualizations to reveal failure modes, boundary instability, and confidence degradation under noise.
5. **Scientific Dissemination**
   Package the findings into:
   - A **CVPR workshop paper** (short-term milestone)
   - An extended **Q1 journal submission** (long-term milestone)

Methodology

1. Dataset Preparation

- Select **2D medical imaging datasets** (e.g., X-ray, fundus, ultrasound, CT slices, or MRI slices).
- Ensure consistent modality in the first phase to enable controlled analysis.

2. Noise Injection & Artifact Simulation

Synthetic noise and artifact perturbations will be introduced during preprocessing, such as:

- Gaussian noise
- Poisson noise
- Salt-and-pepper noise
- Motion blur
- Intensity inhomogeneity
- Low-contrast degradation
- …

Noise levels will be systematically varied to simulate mild to severe acquisition artifacts.

3. Model Benchmarking

- Apply SAM-based models using prompt-based and/or automatic settings.
- Keep inference settings consistent to ensure fair comparison.
- Evaluate robustness across noise types and intensities.

4. Evaluation Metrics

- Dice coefficient
- IoU (Jaccard index)
- Boundary-based metrics (e.g., Hausdorff Distance)
- Stability metrics across noise levels
- Optional confidence/entropy-based analysis

5. Visualization & Analysis

- Side-by-side qualitative comparisons
- Failure case analysis
- Sensitivity plots showing performance degradation trends

Timeline (6 Months Total)

Phase 1: CVPR Workshop Target (Months 1–3)

Goal: Produce a concise, well-controlled benchmark study.

- Run experiments on **2 datasets of the same modality**
- Evaluate a limited but representative set of:
    - SAM models
    - Noise types
- Generate quantitative results and qualitative visualizations
- Write and submit a **CVPR workshop paper**

Compute:

- Google Colab
- Kaggle

Phase 2: Q1 Journal Target (Months 4–6)

Goal: Extend and deepen the study for journal-level contribution.

- Expand to **4–5 datasets** (possibly across modalities)
- Include additional:
    - SAM variants + Conventional models
    - Extended types of Noise injection methods
      Robustness and stability metrics
- Add deeper analysis and discussion on clinical relevance
- Prepare and submit to a **Q1 journal**

Compute:

- AIVN GPU infrastructure
  Private server GPUs