

Project Proposal: Precise Cell Nuclei Segmentation using U-Net

1. Problem Definition and Motivation

1.1 Problem Statement

Accurate detection, segmentation, and quantification of **cell nuclei** in microscopic images is a fundamental yet crucial step in various biological and medical research fields, including cancer diagnosis, drug discovery, and pathology. The size, shape, and distribution of cell nuclei serve as critical biomarkers. However, achieving precise, pixel-level segmentation is challenging due to inherent image complexities:

- Morphological Variability:** Nuclei exhibit diverse, often irregular shapes across different cell types and experimental conditions.
- Clustering and Occlusion:** Nuclei frequently cluster or overlap, making it difficult for traditional methods to separate individual instances.
- Inconsistent Image Quality:** Issues like poor contrast, non-uniform lighting, and image noise complicate boundary delineation.

1.2 Project Goal

This project aims to leverage **Deep Learning** techniques, specifically the **U-Net Convolution Neural Network (CNN) architecture**, to develop an automated model capable of achieving **pixel-level precision** in segmenting cell nuclei. The successful output (a highly accurate segmentation mask) will serve as a reliable foundation for subsequent quantitative analysis (e.g., cell counting, area measurement), significantly enhancing the efficiency and objectivity of biological image analysis.

2. rough time table:

week	things
1	Foundations and Environment Setup
2	Data Pipeline Construction
3	U-Net Core Architecture
4	Initial Training and Loss Implementation
5	Full Training and Optimization
6	Post-processing for Instance Separation
7	Final Evaluation and Comparison
8	Documentation and Finalization