Assignment # 2
(Problem Based Learning)
(CLO4 -> PLO5)
Digital Image Processing
White Blood Cell Analysis and Classification
Submission Deadline: 13 April 2025

Note: Students should score 50% in OBE specific questions to ensure their accumulated scores towards respective PLOs are above 50%

Introduction

Blood, fluid that transports oxygen and nutrients to cells and carries away carbon dioxide and other waste products. It consists of different types of cells suspended in plasma. These cells play crucial roles in oxygen transport, immune defense, and clotting. Blood is primarily composed of:

1. **Red Blood Cells (RBCs)** – Responsible for carrying oxygen.
2. **White Blood Cells (WBCs)** – Involved in immune response and defense against infections.
3. **Platelets** – Assist in blood clotting.

Types of White Blood Cells (WBCs)

WBCs are categorized into **granulocytes** and **agranulocytes** based on the presence of granules in their cytoplasm:

- **Granulocytes**: These have visible granules and include Neutrophils, Eosinophils, and Basophils.
- **Agranulocytes**: These have a clear cytoplasm and include Lymphocytes and Monocytes.

In this problem based learning assignment, we focus on classification of **Neutrophils, Lymphocytes, and Monocytes**, which are identified based on their nucleus shape, size, and cytoplasm characteristics.

Dataset Structure

The dataset consists of two main folders:

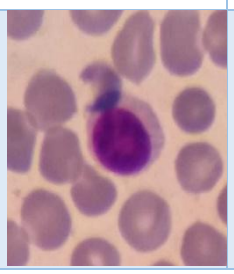
1. **Train Folder**
    - Contains five subfolders:

        - Neutrophil
        - Monocyte
        - Lymphocyte
        - Eosinophil
        - Basophil
    - Each subfolder has 100 images captured at 100x magnification.
2. **Test Folder**
    - Contains the same five subfolders (50 images each).
    - Used for evaluating model performance.

The data is available at following link

https://drive.google.com/file/d/1ngIbP2j5nDbao81IH2VRa-iQGKIDgneM/view?usp=sharing

Rules for White Blood Cell Classification

Feature	Monocyte	Lymphocyte	Neutrophil	Basophil	Eosinophil
Shape of Nucleus	Irregular / Kidney / horseshoe-shaped	Round or slightly oval	Segmented Neutrophil: Multi-lobed (3-5 lobes) Band Neutrophil: U-shaped or curved band-like nucleus	Bilobed or S-shaped	Bilobed
Size of Nucleus	Large, leaves space for cytoplasm	Very large, occupies most of the cell	Moderate-sized, does not occupy whole cell	Small to medium	Medium-sized, not as large as a monocyte
Structure of Nucleus	Loosely condensed chromatin, less dense	Dense, compact chromatin	Segmented, lobulated with thin chromatin strands	Less condensed but often obscured by granules	Condensed, lobulated
Cytoplasm	Abundant, grayish-blue, may have vacuoles	Thin rim of clear or slightly blue cytoplasm	Pale, pinkish cytoplasm with small granules	Granulated, dense granules covering nucleus	Granulated, bright red-orange granules
Color of Nucleus	Light to medium purple	Dark purple, well-defined	Light purple with segmented lobes	Dark purple	Dark purple
Color of Cytoplasm	Light bluish-gray	Very light blue or nearly invisible	Light pink with fine purple granules	Deep blue to purple with granules	Pink to reddish-orange due to large granules
Example					

Use your knowledge about images and design a solution for this problem. You may consider following:

- Preprocessing Step (To enhance cell appearances)
- Feature Extraction (Extract suitable features from images which may be based on color, texture, gradients etc
- Visualize features (use scatter/box plots to visualize features and see if they have any discriminating power)
- Classification (Apply some conditions/thresholds on features to separate them from one another)

Submission Requirements

You need to submit a report (Word or PDF) against this assignment containing:

1. Detailed flow diagram of your solution
2. Feature visualizations
3. 5 class Confusion matrix
4. Tabular results mentioning average per class accuracy

In order to have discussions, we can meet during office hours or feel free to contact through email at usman.akram@ceme.nust.edu.pk