Digital Assignment

Artificial Intelligence

You will work in groups of three. Each batch will focus on a different deep learning technique. You will be assessed based on your implementation, experimentation, performance, and analysis. Complete **Task 1** for **DA1**. For **DA2**, Pick one subtask from **Task 2** based on your group number assigned and then proceed with **Task 3** for **DA3**.

Submission Deadlines:

Digital Assignment 1: 23.01.2025

Digital Assignment 2: 12.03.2025

Digital Assignment 3: 07.04.2025

"While you will be working in groups of four, collaboration should be **within your batch only**. Sharing code, models, or solutions with students outside your batch is considered **academic dishonesty**."

Dataset Information

https://web.inf.ufpr.br/vri/databases/breast-cancer-histopathological-database-breakhis/

The **BreakHis dataset** consists of **7,909 images** of breast cancer tissue, containing both **benign** and **malignant** examples. The images are of size 700x460 pixels and are in **PNG format**. The dataset includes **four magnification levels** (40X, 100X, 200X, and 400X), and it is divided into:

- **2,480 benign samples**
- **5,429 malignant samples**

Task: Binary Classification

You will be classifying each image into either **benign** or **malignant** based on the deep learning models that you implement. You are also expected to analyze the impact of magnification levels and other factors on model performance.

Task 1:

Implement and evaluate a basic CNN model for the classification task.

- Dataset Preparation: Perform necessary preprocessing, including resizing, normalization, and data augmentation.
- Build a CNN architecture(e.g., 3-4 convolutional layers) from scratch using layers such as **Conv2D**, **MaxPooling**, **Flatten**, and **Dense**.

- Evaluate the model using metrics such as **accuracy**, **F1-score**, and **AUC-ROC**.
- Use transfer learning to fine-tune pretrained CNN models **ResNet50, VGG16, or MobileNet**
- Optimize hyperparameters such as **learning rate** and **batch size**.

Task 2:

Sub Task 1: Implement and evaluate Vision Transformers (ViT) for breast cancer image classification.

- Implement ViT using the **HuggingFace Transformers** library or other relevant frameworks.
- Experiment with input image sizes (e.g., 384x384 or 224x224).
- Evaluate the model performance on different magnification levels and analyze its strengths.

- **Expected Output**: Performance comparison between CNNs and ViT models, with attention visualizations.

Sub Task 2: Implement Swin Transformers for breast cancer classification, and compare them with traditional CNNs.

- Implement Swin Transformers using **TensorFlow**.
- Train and evaluate the model on different magnification levels.
- Analyze the impact of patch size and window size on model performance.

- **Expected Output**: Comparative results between CNNs, ViT, and Swin Transformers.

Sub Task 3: Objective: Implement a custom model using Multi-Head Attention for image classification.

- Integrate **Multi-Head Attention** in a CNN architecture to allow the model to focus on important regions in images.
- Experiment with different numbers of attention heads and their impact on performance.
- Evaluate model performance using precision, recall, and F1-score.

- **Expected Output**: Performance analysis and comparison with a basic CNN model.

Sub Task 4: Implement SimCLR, a self-supervised learning method, for image feature extraction.

- Pretrain the model using **SimCLR** on BreakHis without labels.

- Fine-tune the pretrained model for binary classification.
- Compare performance with traditional supervised learning models.

- **Expected Output**: Performance comparison between SSL-based models and fully supervised models.

Sub Task 5: Train models to generalize across different magnification levels.

- Train models on one magnification level (e.g., 40X) and test them on others (100X, 200X, 400X).
- Use **CNNs**, **ViT**, and **Swin Transformer** for cross-magnification generalization.
- Compare the models' ability to generalize across magnifications.

- **Expected Output**: Analysis of model performance across different magnification levels.

Sub Task 6: Implement ensemble learning techniques to improve classification performance.

- Combine multiple models (e.g., **CNN**, **ViT**, **Swin Transformer**) using **voting**, **bagging**, or **boosting**.
- Evaluate the performance of the ensemble model compared to individual models.
- Analyze the performance boost achieved by ensemble methods.

- **Expected Output**: Performance comparison between individual models and ensemble models.

Task 3

Use model interpretability techniques to analyze predictions.

- Implement **Grad-CAM** to visualize which regions of an image influence predictions.
- Use **SHAP** to provide feature-level interpretability of the models.
- Visualize and analyze both correct and incorrect predictions.

Documentation: Prepare a detailed report covering methodology, results, and insights. Include training curves, graphs, and comparisons where applicable.