Task 3 Report: Feature Extraction and Comparison

Introduction

- 3D medical images are expensive to acquire and annotate, resulting in an insufficient number of training images, and a large number of parameters are involved in 3D convolution. So weight inflation is solution.
- **The objective behind comparisions of different layers weight is, how similar or different the learned representations are** between these anatomical regions

Objective

To build a pipeline that extracts region-specific features from a 3D knee CT scan and compares them using deep features from a converted 2D CNN, enabling analysis of anatomical similarity between tibia, femur, and background.

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1. Segmentation-Based Splitting

- The CT scan was split into three anatomical regions: **Tibia**, **Femur**, and **Background** using the segmentation mask.

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2. From 2D CNN to 3D: Weight Inflation

- Standard DenseNet121 pretrained on RGB images (3 channels) was inflated to 3D by repeating 2D convolution filters along the depth axis and normalizing.
- However, due to the mismatch in **domain (RGB vs grayscale)** and **input channels (3 vs 1)**:
    - Filters may not capture meaningful medical features.
    - Learned color-texture dependencies in ImageNet don’t translate well to grayscale CT data.

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3. Feature Extraction Strategy

- For each of the three regions (Tibia, Femur, Background), features were extracted from:
  - **Last**, **third-last**, and **fifth-last** convolutional layers.
- **Global Average Pooling (GAP)** was applied to produce fixed-length feature vectors.
- Consideration: earlier/mid-level features might generalize better from 2D pretrained weights due to domain shift.

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4. Feature Comparison

- Cosine similarity was computed between:
  - Tibia ↔ Femur
  - Tibia ↔ Background
  - Femur ↔ Background
- At all three layers (last, third-last, fifth-last) to assess:
  - How discriminative the learned features are between bone types and non-bone tissue.
  - Whether different layers capture low-level vs high-level anatomical differences.

Conclusions:
The features between femur and tibia are highly correlated than with background.