Deep Learning-Based Denoising Techniques in Medical Imaging

- **Student ID**: 2690201
- **Module Name**: Current Topics in Data Science
- **Degree Programme**: MS Data Science
- **Overview**: Introduction to the critical role of denoising in enhancing the quality of medical images across various modalities including ultrasound, PET, and CT.

Highlights of the Topic

- **Deep Learning in Medical Imaging**:
  - Traditional denoising techniques vs Deep Learning
- **Innovative Frameworks**: Overview of frameworks like
  - UNiversal Anatomy-initialized Noise Distribution Learning Framework UNAD (Lingrui , Deng , & Wang 2024).
  - Content-Aware Prior and Attention-Driven CAPAD (Lin et al 2023).
  - U-NET Convolutional Neural Network (Murata et al 2024).
  - Detection task-specific deep-learning-based approach for denoising MPI SPECT images DEMIST (Rahman et al 2023).
  - Positron Emission Tomography PET (Johnson et al 2019; Cu et al 2019) others
- **Advancements and Motivation**: Discussion on the significant improvement in image quality, diagnostic accuracy, and patient safety by reducing the need for high radiation doses.

Main Applications

- **Ultrasound Image Denoising**: Enhancing fetal imaging and tumor detection.(CNN,GRADIENT BOOSTING MACHINE)
- **PET Image Denoising**: Improving clarity in oncology, neurology, and cardiology images.
- **CT Image Denoising**: Reducing radiation exposure while maintaining diagnostic quality.
- **DL-Filtered Denoising:** The deep learning method has demonstrated good image quality improvement and diagnostic performance for low count bone scintigraphy, suggesting its applicability to clinical practice
- **Cross-Modality Applications**: How these techniques can be adapted across different imaging modalities for broader healthcare impacts.

Open Research Questions

- **Noise Model Complexity**: Exploring more complex noise models beyond Gaussian assumptions.
- **Transfer Learning and Universality**: How to develop more adaptable models that can be easily transferred across different imaging modalities and anatomical structures.
- **Interpretability and Trust**: Addressing the challenge of making deep learning models more interpretable for clinicians.

Main Challenges

- **Data Availability and Annotation**: The scarcity of high-quality, annotated low-dose medical images for training.
- **Model Generalization**: Ensuring models trained on one dataset can perform equally well on another, unseen dataset.
- **Balancing Detail Preservation with Noise Reduction**: Finding the optimal balance between removing noise and preserving crucial details in medical images.
- **Computational Resources**: The high demand for computational resources and efficient processing time for training and applying these deep learning models in a clinical setting.