CSYE7374 - Deep Learning and Generative Modeling in Healthcare

Homework Assignment: Neural Networks for Medical Data Analysis

Due Date: Oct 12, 2025
Total Points: 100
Submission Format: Jupyter notebook (.ipynb) with all code, outputs, and written explanations

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Instructions

- Complete all questions in a single Jupyter notebook
- Show all outputs including plots and metrics
- Use PyTorch for all implementations
- Set random seeds for reproducibility (seed=42)
- You may use the provided course notebooks as reference

Question 1: CNN Architecture (25 points)

Using the PathMNIST dataset from the course materials:

Part A (10 points)

Implement a modified CNN architecture that includes:

- At least one residual connection (skip connection)
- Dropout layers with different rates for convolutional and fully connected layers
- A global average pooling layer instead of flattening before the classifier

Your model should have between 500K and 2M parameters. Print the model summary showing the number of parameters.

Part B (10 points)

Train your modified model for 15 epochs and compare it with the baseline model from class:

- Plot training/validation loss and accuracy curves for both models on the same plots
- Report final test accuracy, precision, recall, and F1-score for each class
- Create a confusion matrix heatmap for your modified model

Part C (5 points)

Implement and visualize feature maps from the first and last convolutional layers for 3 test images. Explain what patterns the network appears to be learning at different depths.

Question 2: RNN/LSTM Time Series Analysis with Clinical Data (35 points)

Using the PhysioNet Challenge 2012 dataset from the course materials:

Part A (15 points)

Implement a bidirectional GRU (Gated Recurrent Unit) model as an alternative to the LSTM:

- Use the same input features and preprocessing as the course notebook
- Implement both with and without attention mechanism
- Your GRU should have comparable parameter count to the LSTM model

In markdown explain how GRU gates differ from LSTM gates.

Part B (10 points)

Implement a custom attention mechanism that:

- Uses multi-head attention (at least 4 heads)
- Includes positional encoding for the time steps
- Visualizes attention weights for 5 test patients (show heatmaps)

Compare the performance with the single-head attention from class.

Part C (10 points)

Perform ablation studies by training models with:

1. Only heart rate and blood pressure features
2. Only the first 12 hours of data
3. Different sequence lengths (6, 12, 18, 24 hours)

Create a table comparing AUROC, AUPRC, and F1-scores for each configuration.

Question 3: Model Optimization and Deployment Considerations (15 points)

Part A (7 points)

Choose either your CNN from Q1 or LSTM from Q2 and:

- Implement model pruning to reduce parameters by 30%
- Apply quantization to reduce model size
- Compare inference time and accuracy before/after optimization
- Report model sizes in MB

Part B (8 points)

Implement early stopping and learning rate scheduling:

- Use ReduceLROnPlateau scheduler
- Implement patience-based early stopping
- Add model checkpointing to save best model
- Plot learning rate changes during training
- Compare convergence with and without these techniques

Submission Requirements

Your notebook should include:

1. All code implementations
2. Output displays
3. All requested plots and visualizations
4. Written explanations where requested