Assignment 3 – https://ml4n.stanford.edu

(Starter code *[Python-only]* and data) You have been provided with a resting-state fMRI connectome dataset of 120 individuals diagnosed with Autism Spectrum Disorder (ASD) and 120 typical controls. Each connectome, i.e., each subject's brain network and properties, is encoded as an *N*-by-*N* correlation matrix **M**, where $\mathbf{M}_{i,j}$ is the functional connectivity (correlation in activation patterns) between region *i* and region *j*.

Q1. Use an approach of your choice (machine learning or statistical group analysis) to identify noticeable differences in correlation values between control subjects and those diagnosed with ASD. Based on your findings, what are the implications of these findings in understanding ASD impact on brain function? Feel free to use supporting literature to cite your claims. See this tutorial on functional connectome analysis.

Q2. Assume that the correlation matrix represents a graph where the nodes are the ROIs, and the edge weights are the correlation values. Apply graph theory metrics to analyze the constructed networks and whether the two cohorts are significantly different in the metrics. Metrics/analyses might include (see starter code for examples):

- Weight Distribution: distribution of the edge weights (correlation values). This can include calculating the mean, median, standard deviation and creating histograms or density plots.
- Weighted Degree: Instead of just counting connections sum the weights of the edges connected to each node. This gives an idea of how connected a node is and how strong those connections are.
- Weighted Clustering Coefficient: The degree to which nodes tend to cluster together while considering the weights of the edges.
- Community Detection:
    - Modularity-Based Clustering: Use algorithms like Louvain or Girvan-Newman to detect communities or clusters within the graph. These methods can be adapted to consider edge weights.
    - Community Structure Analysis: Once communities are detected, analyze their properties, such as the number of nodes, average weight of edges within and between communities, etc.

Feel free to consult the following resources for graph network analysis on connectomes.

- BrainGB (Cui et al., 2023)
- xGWGAT (Nerrise et. al, 2023)
- IBGNN (Jie et al., 2022)
- RegGNN (Hanik et al., 2022)