Classification and Analysis of Alzheimer's Disease using Deep Learning on Neuroimaging Data

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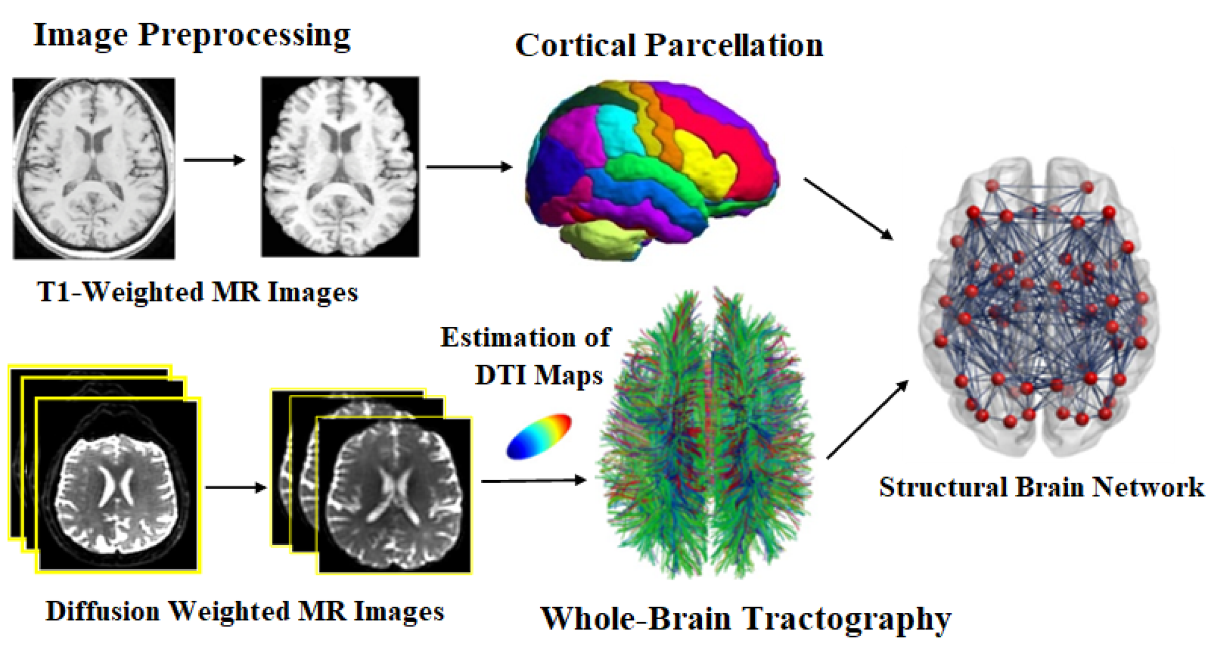
Background

- Alzheimer's Disease (AD) is a progressive neurodegenerative disorder affecting the elderly and the leading cause of dementia without a known cure.
- Deep Neural Networks have shown state-of-the-art outcomes in medical imaging, including AD detection, and enable interpretable analysis of classification decisions.
- Changes in structural connectivity of the Alzheimer's brain have not been widely studied utilizing cutting-edge methodologies.
- Our research proposes novel algorithms utilizing structural brain networks and deep learning to detect AD and identify associated white matter changes in AD.

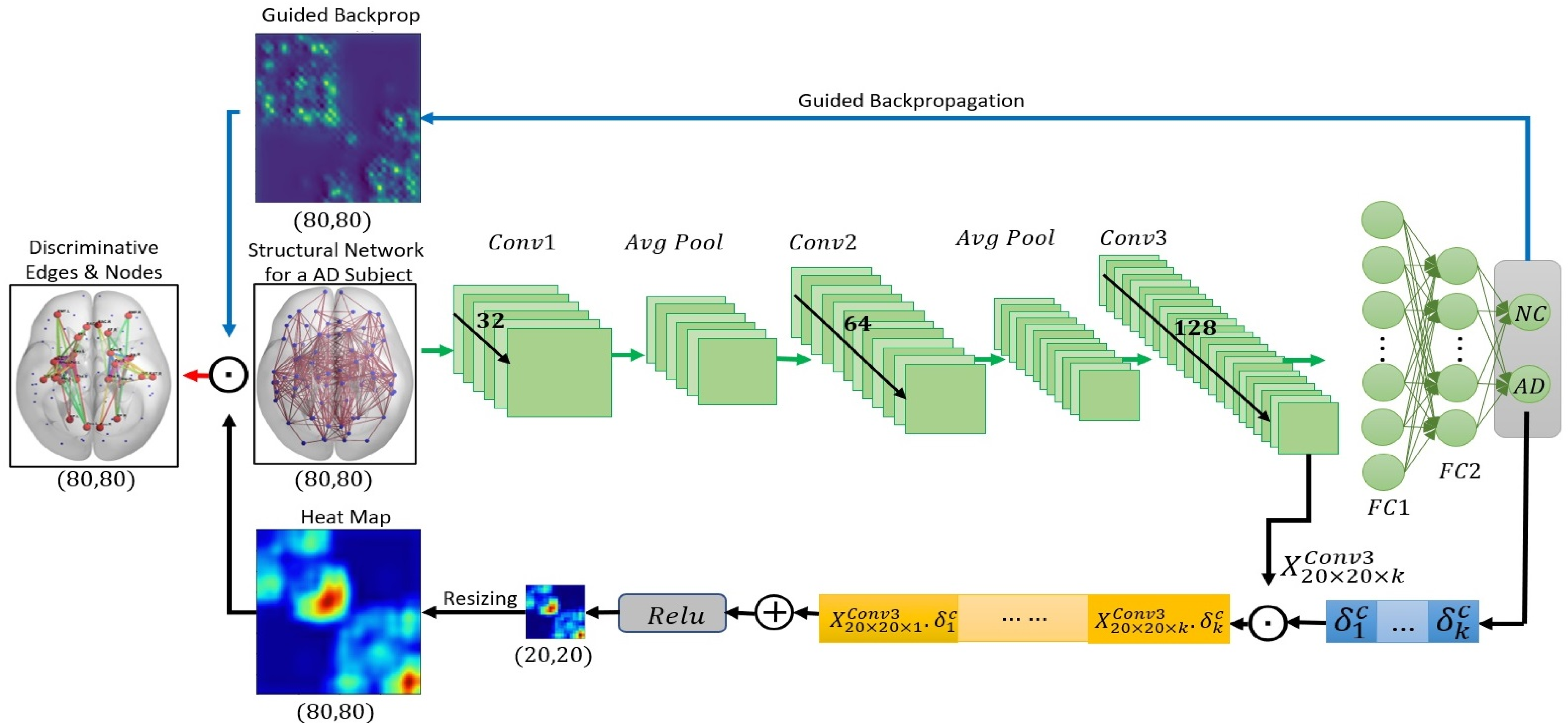
Contribution

- Generating structural brain networks for AD patients and healthy controls.
- An efficient Convolutional Neural Network(CNN) framework is developed to accurately detect AD and analyze the CNN's classification choices and identify discriminative changes in white matter connectivity.
- An efficient CNN-based approach investigates asymmetrical white matter changes in AD using left and right hemispherical brain networks.

Structural Brain Network

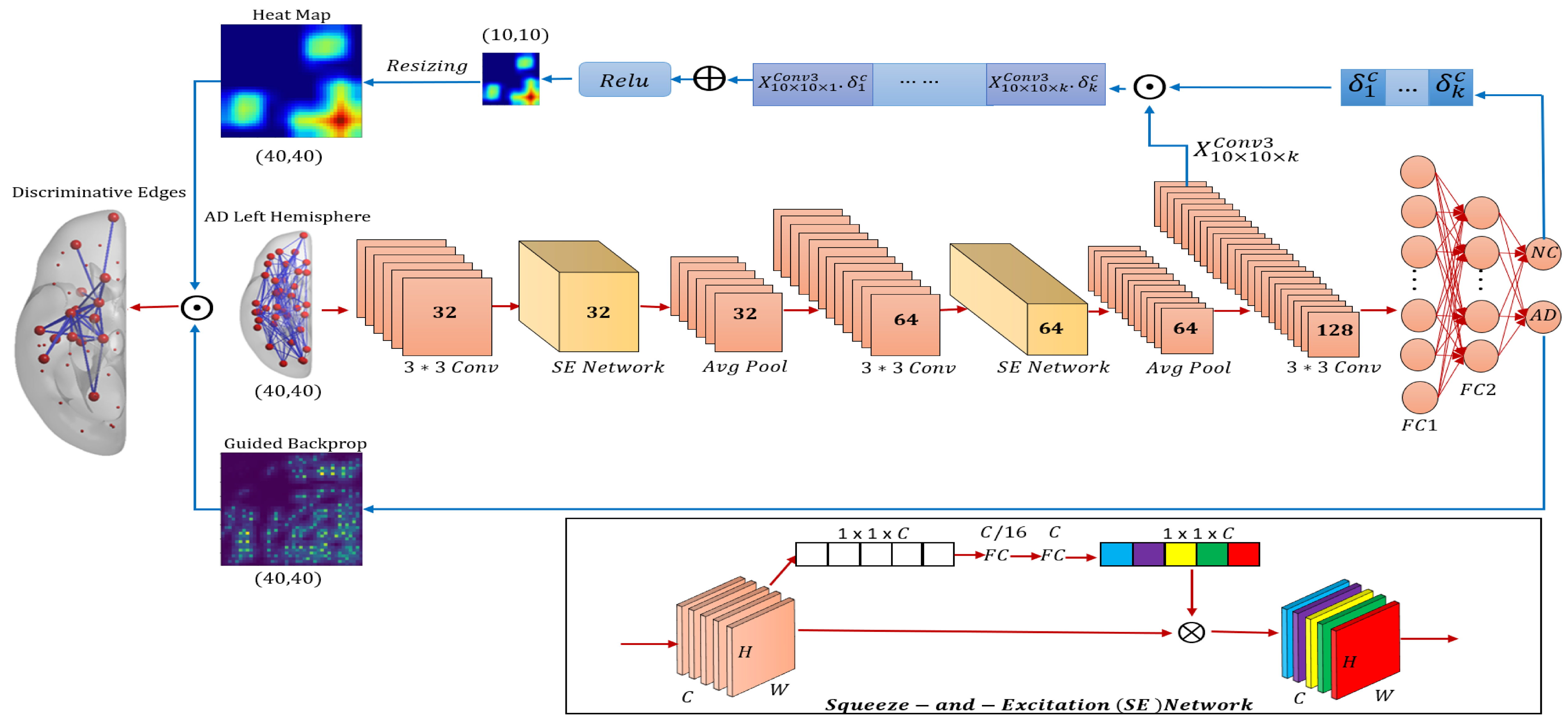


CNN & CAM Visualization for AD & NC



The adjacency matrix of a test subject is input to the trained CNN classifier.
The guided backpropagation and heatmap are obtained.
Then multiplied through an element-wise multiplication operation to obtain the Gradient-weighted Class Activation Mapping (Grad-CAM).

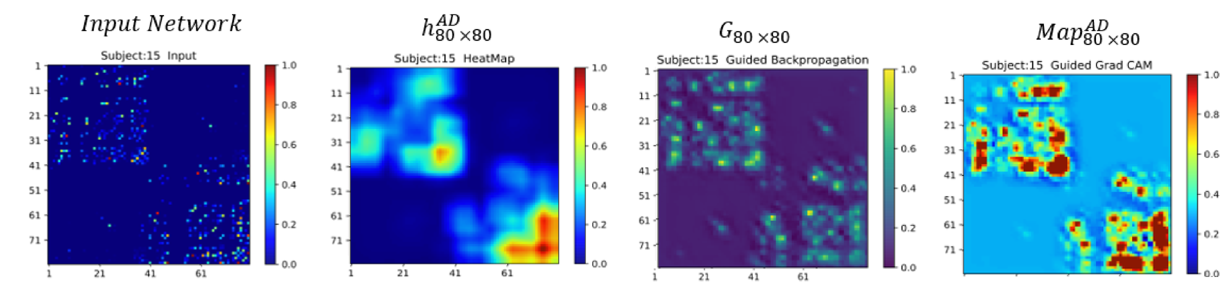
CNN & CAM Visualization for Left & Right Hemispheres

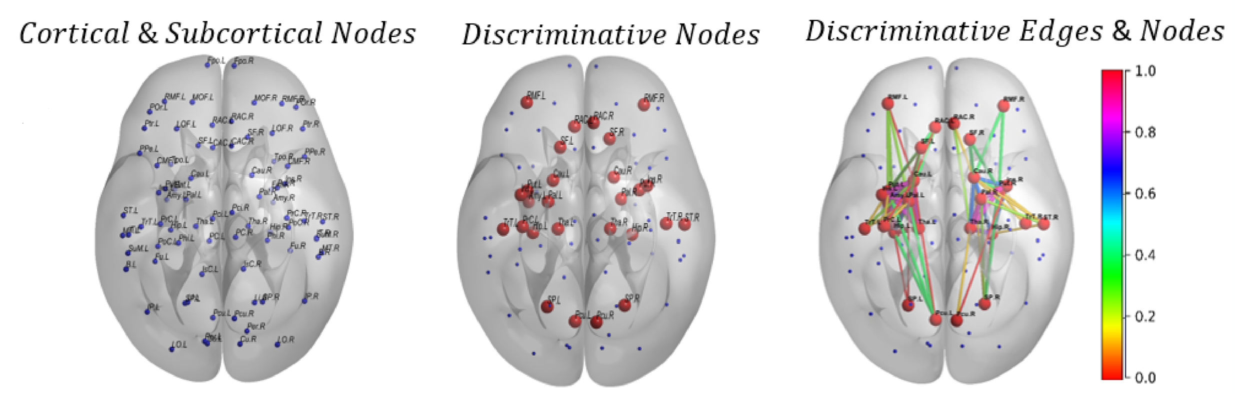


The proposed CNN model consumes the structural brain network of the left or right hemisphere with dimensions of 40 × 40.
A visualization technique based on the Grad-CAM approach was developed.
Generate activation maps for the AD class on the input data.
The corresponding regions in the structural brain network and white matter pathways were identified.

Results

- The proposed CNN architecture for AD & NC classification showed 95% average accuracy.
- A distinct pattern was discovered, revealing significant white matter changes within the temporal/subcortical regions and between the temporal/subcortical regions and the frontal and parietal regions.





- By applying the proposed CNN model for hemispheres, an average classification accuracy of 97% for the left hemisphere and 95% for the right hemisphere was achieved.
- Identifies discriminative asymmetrical changes, including distinct connectivity changes within the left and right hemispheres, pronounced changes primarily in the left hemisphere, and discriminative changes involving subcortical regions in both hemispheres.