Graph Neural Network

Example 1: GNN for brain networks

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Course 2024-25

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Introduction

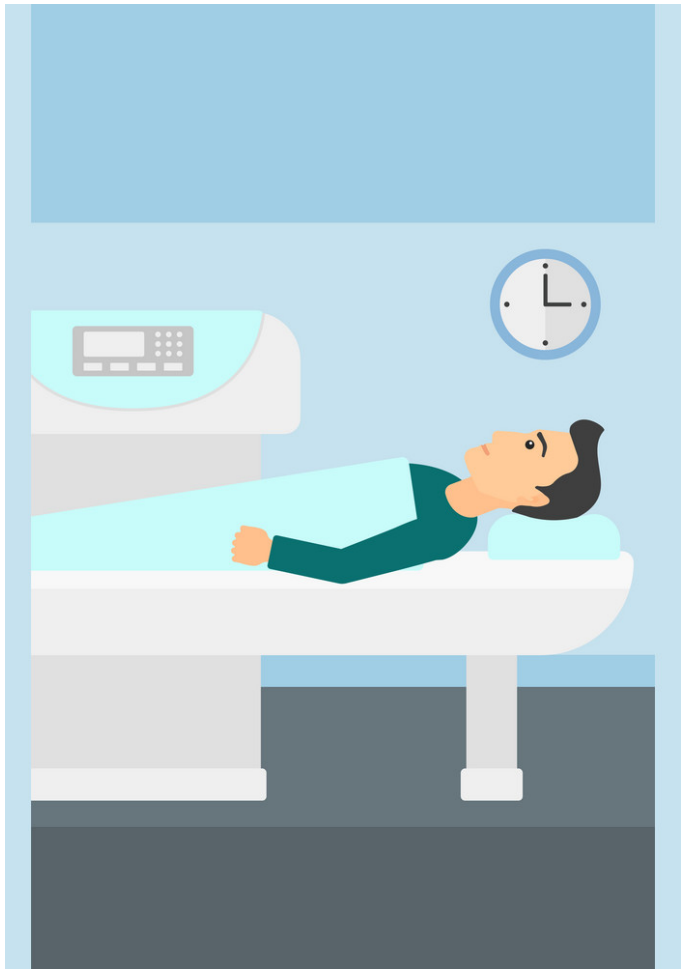
Multiple Sclerosis (MS)

- **Multiple Sclerosis** (MS) is a chronic inflammatory and neurodegenerative disease of the central nervous system that leads to physical and cognitive disability, that affects millions of people worldwide.
- The presence of demyelinating lesions in brain MRI is essential in **diagnosing**, **monitoring** disease progression, and **evaluating** treatment response.
- Identifying new MS lesions is a complex task due to their variable size and brain locations.

Introduction

Magnetic Resonance Acquisition (MRI)

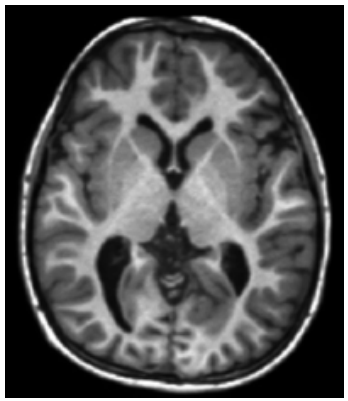
- **Magnetic resonance imaging** (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body.
- Using **diffusion-magnetic resonance imaging** (MRI), abnormalities in structural brain connectivity have been seen to be driven by demyelinating and neuroaxonal damage in patients with MS.



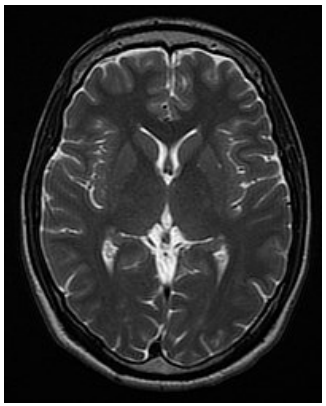
Introduction

Magnetic Resonance Image

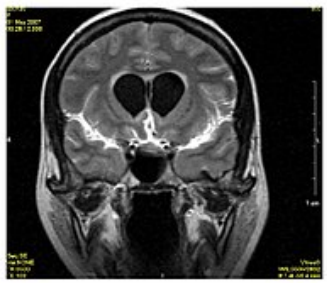
- T1 weighted
  - Lower signal for more water content, as in edema, tumour, infarction, inflammation, infection, hyperacute or chronic haemorrhage.
- T2 weighted
  - Higher signal for more water content.
- FLAIR
  - High signal in lacunar infarction, multiple sclerosis (MS) plaques, subarachnoid haemorrhage and meningitis
- Grey-scale 3D images, $192 \times 256 \times 256$.



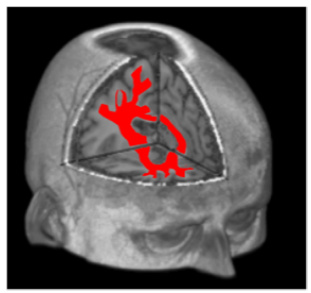
(a) T1



(b) T2



(c) FLAIR

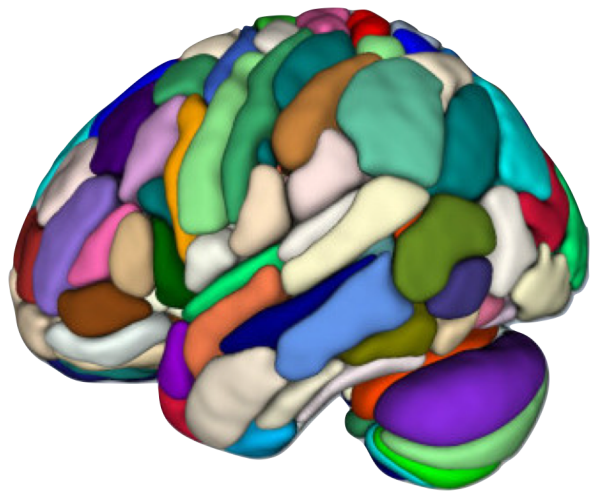


(d) 3D

Introduction

Magnetic Resonance Image

- Anatomical parcellation scheme
  - The anatomical cortical parcellation computed by Mindboogle (Desikan et al., 2006).
  - The nodes of the three brain networks constructed are the 76 brain regions depicted.

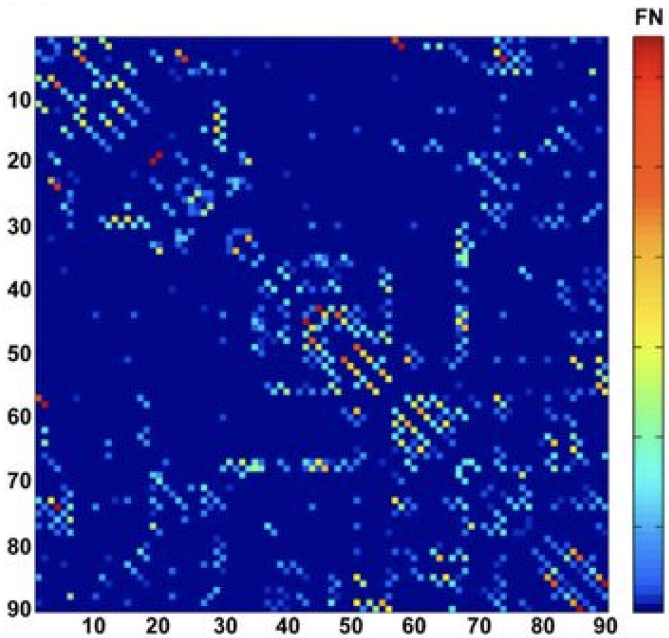


Introduction

Brain Matrices

For each subject:

- Structural brain connectivity matrix (**DTI**)
  - FA-weighted adjacency matrix of the network, 76×76.
- Morphological gray matter brain matrix (**GM**)
  - Similarity of GM morphological patterns according to the defined anatomical parcellation scheme.
- Functional brain matrix (**rs-fMRI**)
  - Brain signal correlation/synchronization through resting-state functional connectivity matrix.

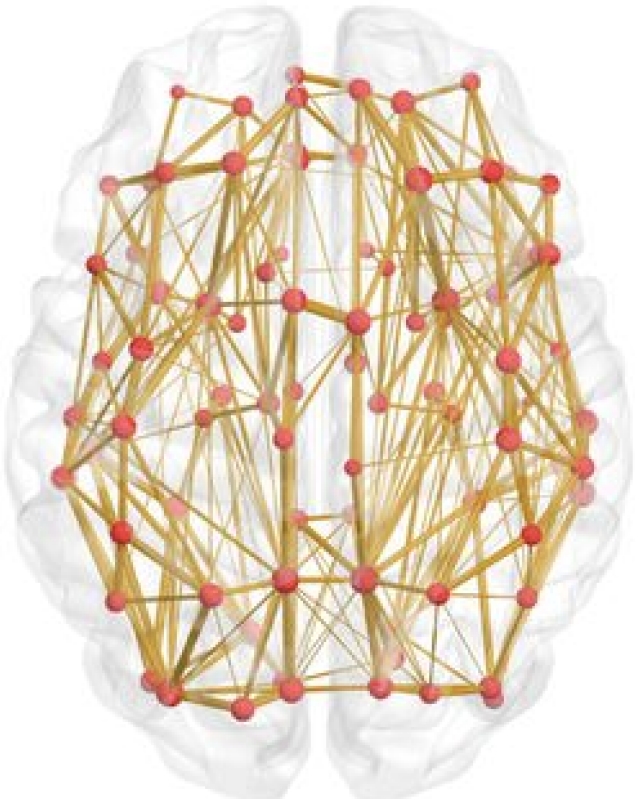


Introduction

Brain Networks

For each subject:

- Structural brain connectivity network (**DTI**)
  - The values are in the range [0, 1].
- Morphological gray matter brain network (**GM**)
  - The values are in the range [0, 1].
- Functional brain network (**rs-fMRI**)
  - The values are in the range [-1, 1].



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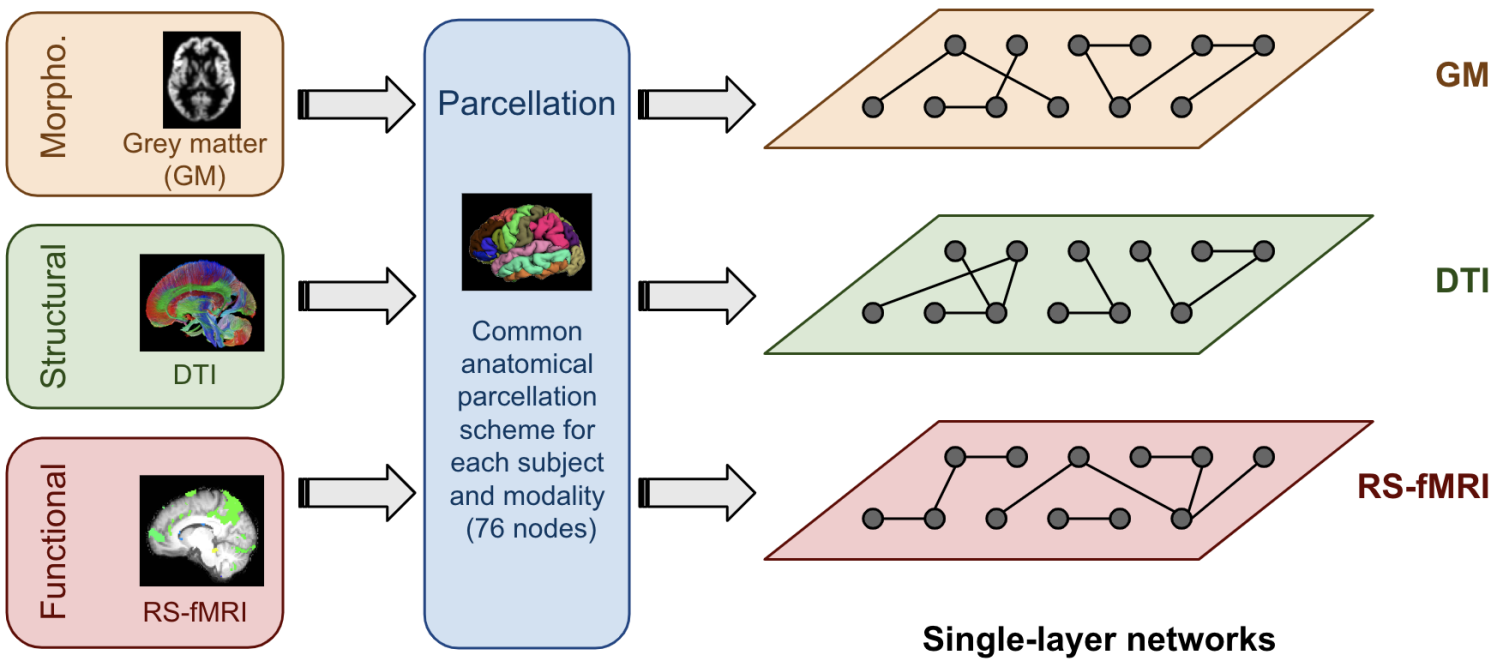
Single-Layer approach

Architecture



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Graph Neural Networks

Objectives

Objectives:

- Use the power of GNNs to predict the state and evolution of an MS patient.
- Specifically, we use the Graph Convolutional Networks (GCN).
- Classification problem:
  - Healthy Volunteers (HV)
  - People with MS (pwMS)

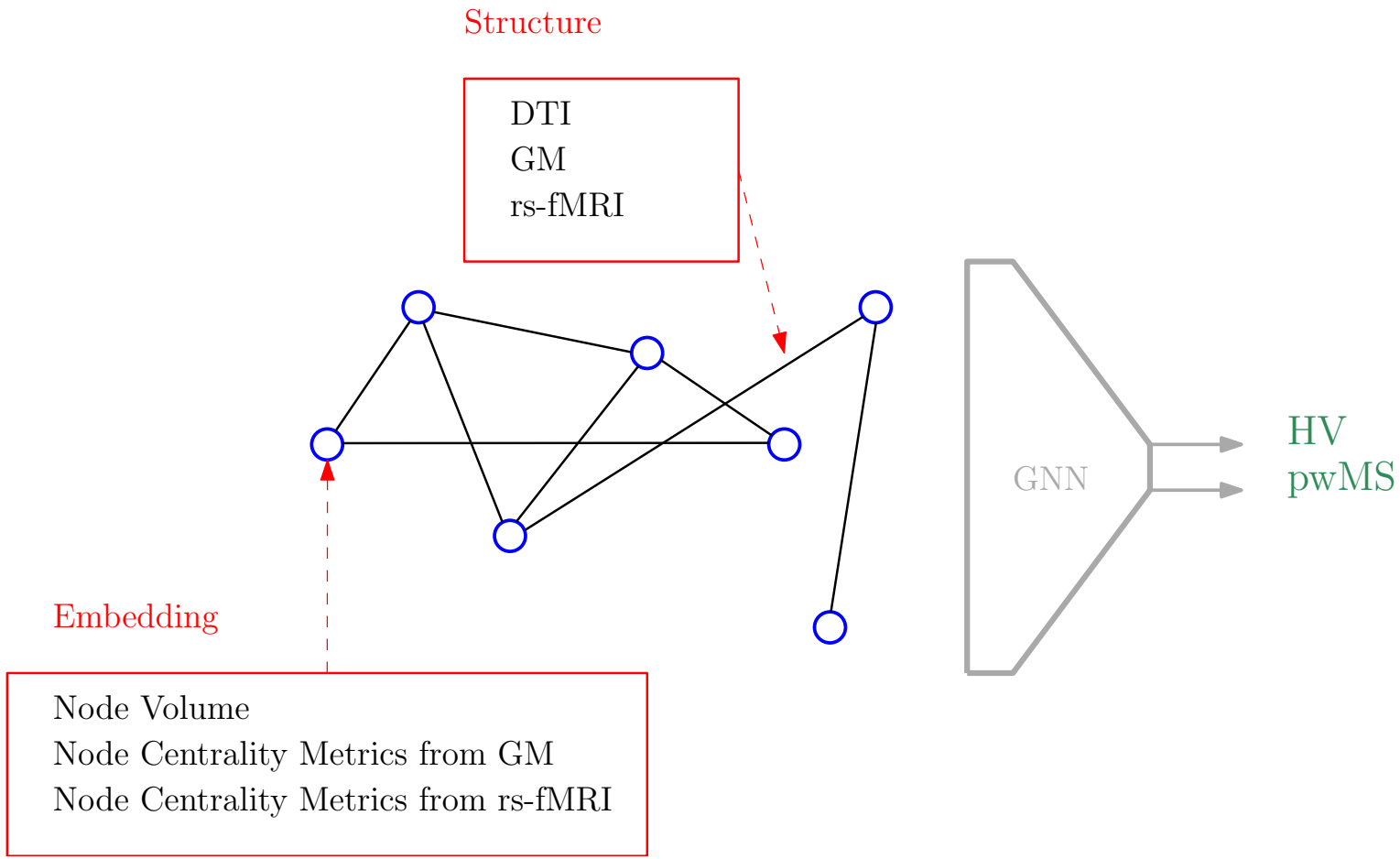
Graph Neural Networks
Design

Design decisions:

- **Graph connectivity**:
  - derived from the DTI network information?
  - or GM or rs-fMRI?
  - Combination of them (pseudo-graph or multi-layer graph)?
- **Node embeddings**:
  - node volume (NA!)
  - node metrics computed from the DTI, GM or rs-fMRI graphs?

Graph Neural Networks

Architecture



Thank you!

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