Background

- 1H Magnetic Resonance Spectroscopy (MRS) provides detailed tissue metabolism information that has clinical potential to improve the non-invasive characterization of brain tumors.
- A major challenge faced by multi-voxel Magnetic Resonance Spectroscopy (MV-MRS) imaging is the partial volume effect (PVE), which results in a mixture of signals from two or more tissues within a MRS voxel.
- At present the definitive diagnosis of a brain tumor can only be confirmed by histological examination of tumor tissue samples obtained either by means of brain biopsy or open surgery.

Methodology

- The brain tumor grade is correlated with the MRS signal, e.g. a decrease in levels of N-acetylaspartate (NAA) indicates neuronal loss or damage [1].
- We use this relation to propose a Signal Mixture Model (SMM) for characterizing brain tissue as normal, low grade (infiltrative), and high grade (necrotic), respectively.
- PCA is applied on a database of single-voxel MRS (SV-MRS) signals to model each tissue type in terms of its mean, and variation about the mean.

Signal Mixture Model

- For each tumor grade $i \in \{n, l, h\}$, we produce a signal model

$$m_i(t) = \mu_i(t) + \sum_{k=1}^{K_i} \omega_{ik} \mathbf{v}_k(t).$$

- A MV-MRS signal can then be modelled as

$$s(t) = \omega_0 \mathbf{m}_0(t) + \omega_1 \mathbf{m}_1(t) + \omega_2 \mathbf{m}_2(t).$$

- where $\omega_0, \omega_1, \omega_2$ are mixture coefficients that represent the probability of each tumor grade in $s(t)$ and are constrained by

$$\omega_0 + \omega_1 + \omega_2 = 1 \text{ and } \omega_0 \geq 0, \omega_1 \geq 0, \omega_2 \geq 0.$$

Results

- Our dataset consists of 137 SV-MRS for training the SMM model and 30 MV-MRS patients, with ground truth histological diagnosis, for validation.

Conclusion

- The proposed SMM based method enabled non-invasive detection of brain tumor which has the potential for a computer-aided diagnosis tool with the far-reaching impact of surgical treatment and radiotherapy planning.