Theme 7 – Neuroimaging Poster # 60

Towards highly-automated detection of white matter injury in prematurely born babies from diffusion tensor MRI.

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Abstract:

Non-cystic white matter injury (WMI) is one of the most common abnormalities in premature newborns and has been shown to increase the risk of cognitive and motor impairments. Images generated using the relatively new diffusion tensor magnetic resonance imaging technique have proven informative when assessing white matter tract health and maturation. Thus, diffusion tensor imaging (DTI) data is important for the early diagnosis of possible motor impairment, symptomatic of cerebral palsy. However, recent advances in imaging technologies (particularly DTI) have outpaced the capacity of most radiologists to determine what is "abnormal", and thus the use of software to aid in the analysis of this data is vital. In this work, our goal is to extract features from DTI data that improve the detection of WMI in infants, aiding in the diagnosis of neurological disorders and in the understanding of early brain development. To this end, we train a Support Vector Machine (SVM) classifier by employing a cohort of 90 preterm newborns, born at gestational ages between 24 to 32 weeks, and imaged using DTI up to 3 different time points before 47 weeks gestational age. Each image is manually scored for the presence of WMI from 0 to 3. Tractography is then performed on each image to determine the structure of prominent fiber tracts in each image. Since FA is an indicator of tract coherence, which is expected to be lower in areas of WMI, we train our WMI classifier based on the dissimilarity between the average FA along corresponding tracts in different images. Correspondence was established based on tract shape and location. Given a novel brain image, we calculate its similarity to each image in the training set and use the trained SVM to provide a classification of WMI. Using leave-one-out validation, we are able to predict the existence of WMI in 83% of cases and predict the exact WMI score (from 0 to 3) in 47% of cases. We note there is typically less variance in our similarity metric when both images exhibit WMI than when one or both images are of a healthy brain. Qualitatively, this is indicative of greater homogeneity (in both shape and FA) of the tracts traced out in injured brains. This study is a step towards better understanding and diagnosis of WMI in premature newborns.

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Automated Detection of White Matter Injury from Diffusion Tensor MRI

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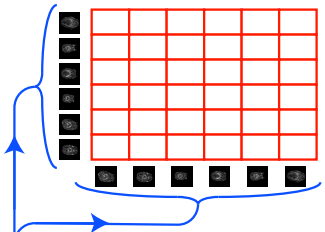
Overview:

- White matter injury (WMI) is one of the most common abnormalities in premature newborns
- Increased risk of cognitive and motor impairments.
- Diffusion tensor magnetic resonance imaging (DTMRI) useful for assessing WMI.
- Important for early diagnosis.
- Difficult to determine what is "abnormal" in DTMRI.
- Software to aid in the analysis is of vital.
- Build automatic WMI classifier from training data.

Tracts' Features:

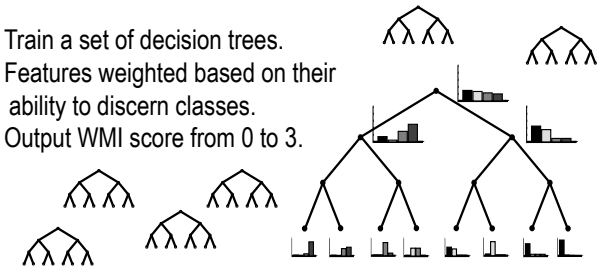
- Fiber tracts compared based on:
  - spatial location
  - orientation
  - fractional anisotropy
  - length
  - diffusion strength
  - relative diffusivity
- Tract comparison used to find an overall image similarity features.



Training

Random Forest Classifier:

- Train a set of decision trees.
- Features weighted based on their ability to discern classes.
- Output WMI score from 0 to 3.

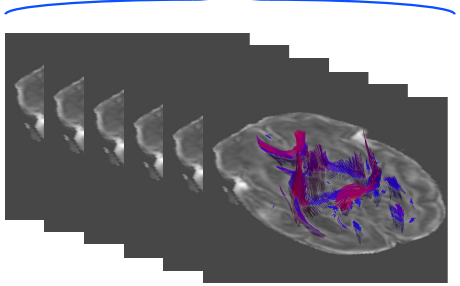


Classifier Input

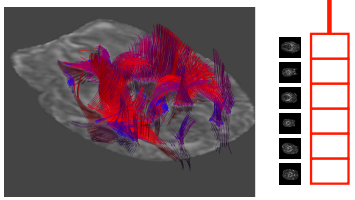
Output WMI Score
(from "None" to "Severe")

Training Data:

Cohort of 357 DTMRIs:
- Gestational ages from 24 to 32 weeks.
- Imaged up to 3 times before 47 weeks age.
- WMI severity assigned 1 of 4 classes: {0,1,2,3}.
- Computational tractography performed on each image to extract fiber tracts.



Novel Image:



- Leave-one-out from training data.
- Features extracted by comparison with training data.
- Input features to random forest.

Results:

Identifying the Presence of Significant White Matter Injury (95% Confidence Intervals):

True Positive: [0.572, 0.809]
True Negative: [0.446, 0.558]

Acknowledgements:

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