

Classification of Malignant & Benign Peripheral Nerve Sheath Tumors

WITH AN OPEN SOURCE FEATURE SELECTION PLATFORM

Michael Zhang, MD

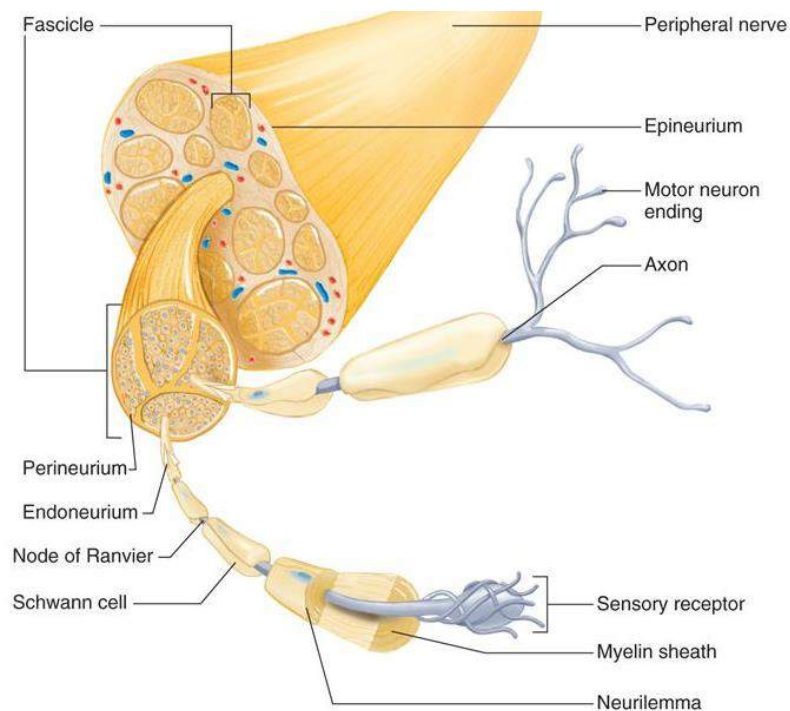
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April 22, 2020 – Day 37

Outline

Goal: Develop a binary classifier (Malignant/Benign) with MRI

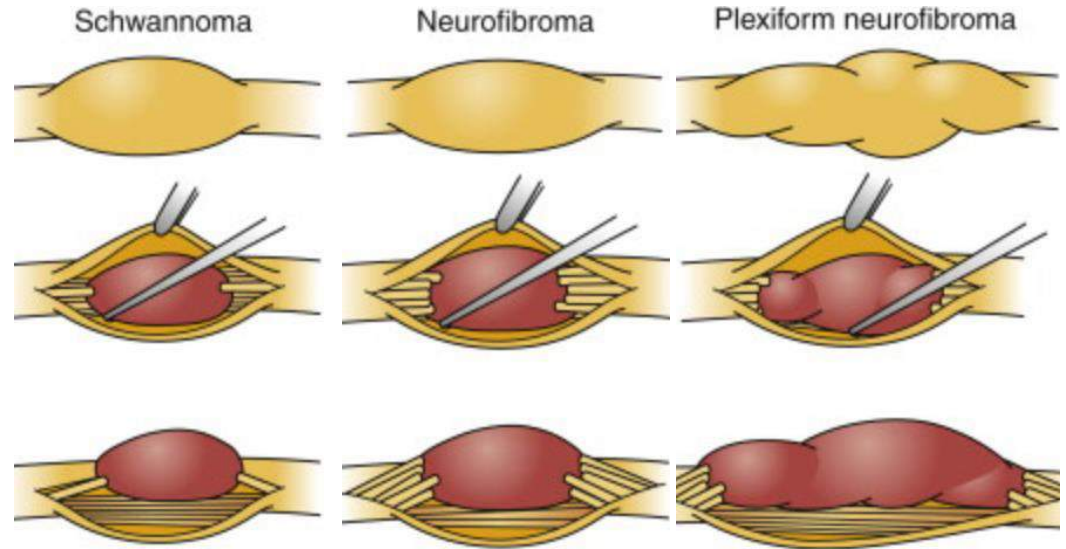
- **Background:**
 - › **Malign and Benign PNST**
 - › **Current Clinical Workflow**
- **Methods:**
 - › Feature Selection: QIFP
 - › Feature Optimization
- **Results**
- **Future Directions**



Malignant and Benign PNST

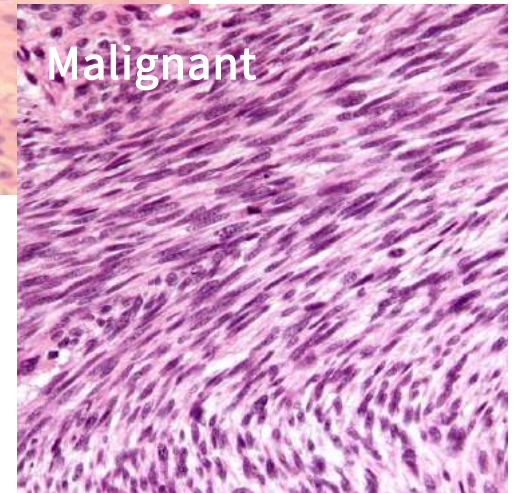
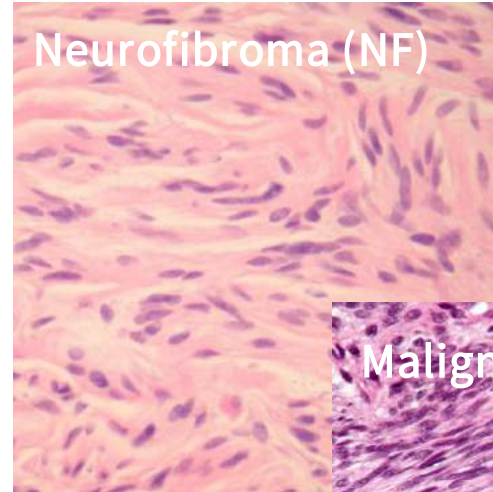
Peripheral Nerve Sheath Tumors

- Benign
 - › Neurofibroma
 - › Schwannoma
 - › Perineuroma
 - › Hybrids
 - › Ganglioneuroma
- Malignant
 - › MPNSTs
 - › Sarcomas
 - › Metastasis



MPNST – Can't Miss Diagnosis

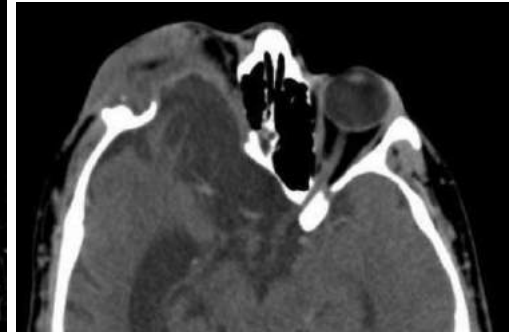
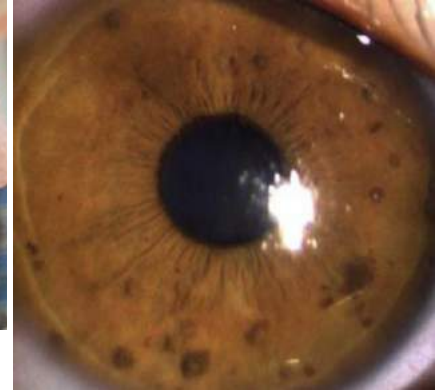
- Natural History
 - › **5-year survival 30-50%**
 - › 50% occur in Neurofibromatosis (NF1)
 - › 5-10% subset of total NF1
- Pathophysiology
 - › **Malignant Transformation**
 - › NF → Plexiform → Malignancy
 - › Invasion and metastasis → morbidity and surgical difficulty



Neurofibromatosis 1 (NF1)

Clinical History

- Criteria (2 of 7)
 - › Café-au Lait Spots
 - › Axillary/Inguinal Freckling
 - › Neurocutaneous Lesions
 - › Optic gliomas
 - › Iris hamartomas
 - › Sphenoid Dysplasia
 - › Axillary/Inguinal Freckling
 - › First degree relative



Current Approaches

Treatment: Surgical Cure

Diagnosis

- **MRI:**
 - › Qualitative features
 - › ADC
 - › DTI
- **PET: SUV > 3.5**
- **Gold Standard: Surgical Biopsy**

Wasa et al. - MRI Criteria

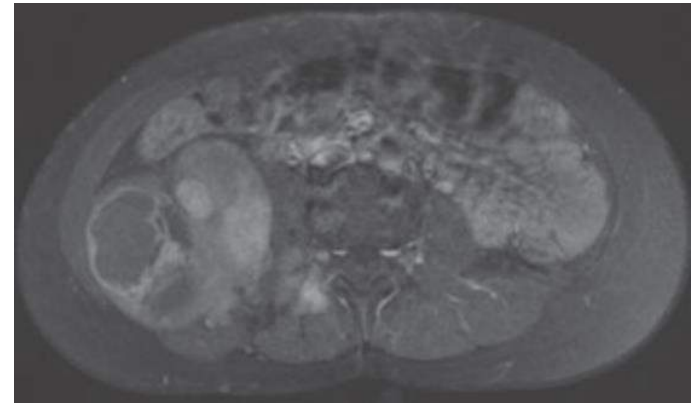
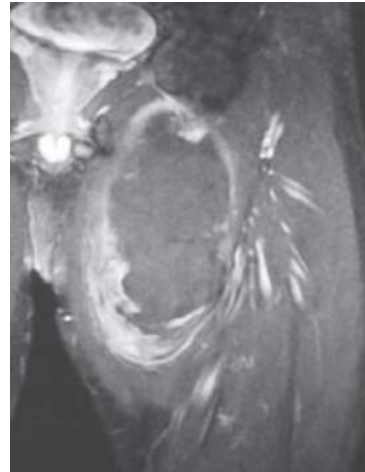
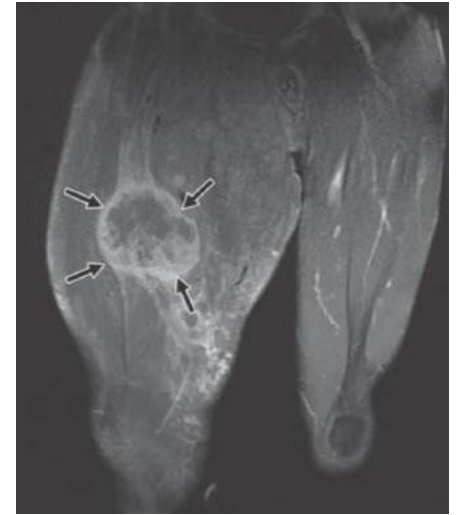
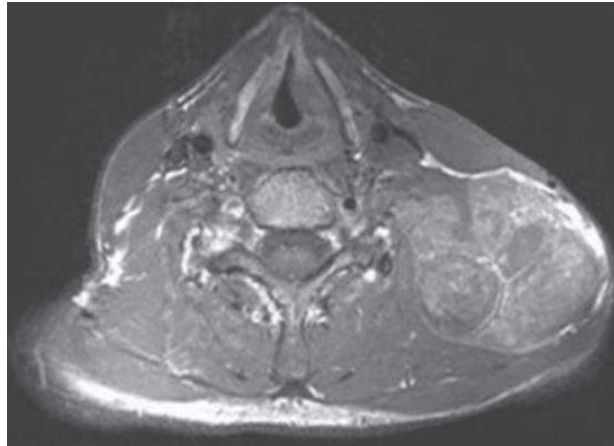
With 2 of 4 – 61% sens, 90% spec

1. Diameter > 5 cm
2. Peripheral tumor enhancement
3. Perilesional edema
4. Intra-tumoral cyst

Radiographic Ambiguity

MRI T1 with Gad Fat Sat

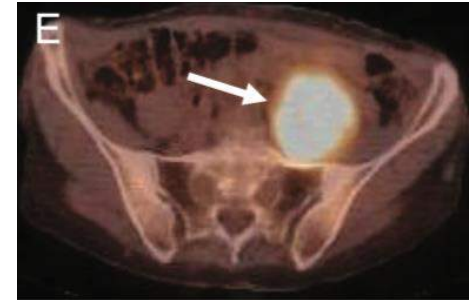
- Neck – NF1
- Right Thigh – Plexiform with malignant transformation
- Left Thigh – MPNST
- Right RP – MPNST



Additional Tools: PET, Derlin et al.

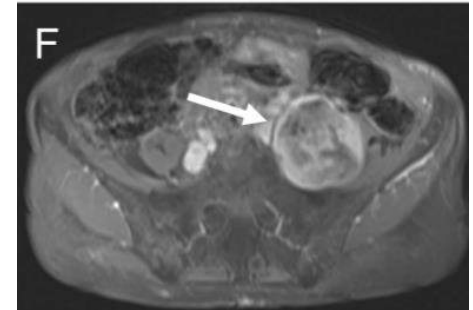
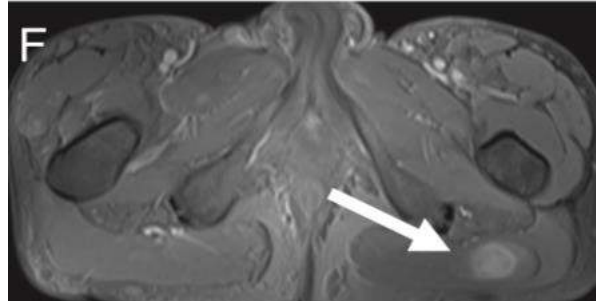
SUVmax ≥ 3.5

- 100% Sensitive
- 54.5% Specific
- 47.4% PPV



MRI comparison

- 66.7% sensitive
- 90% specific
- 75% PPV



Surgical Morbidity

MPNST, Surgical Goal: complete resection without damaging function—total resection is curative

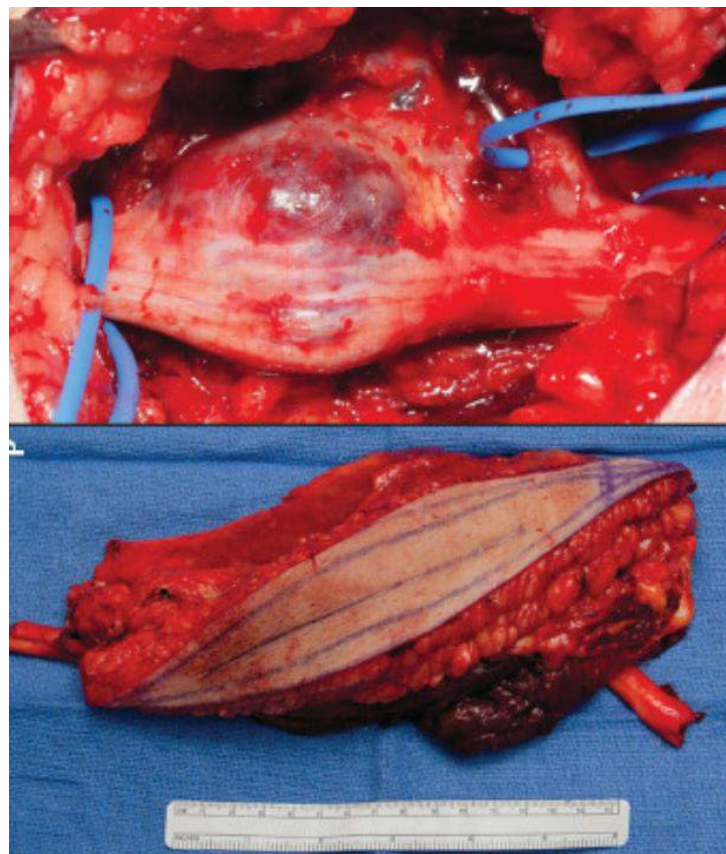
Benign, Schwannoma: simpler procedure involving, single nerve root and displacing uninvolved fascicles

Benign, NF: single or multiple nerves can traverse tumor → possible functional implications



Surgical Morbidity: MPNSTs

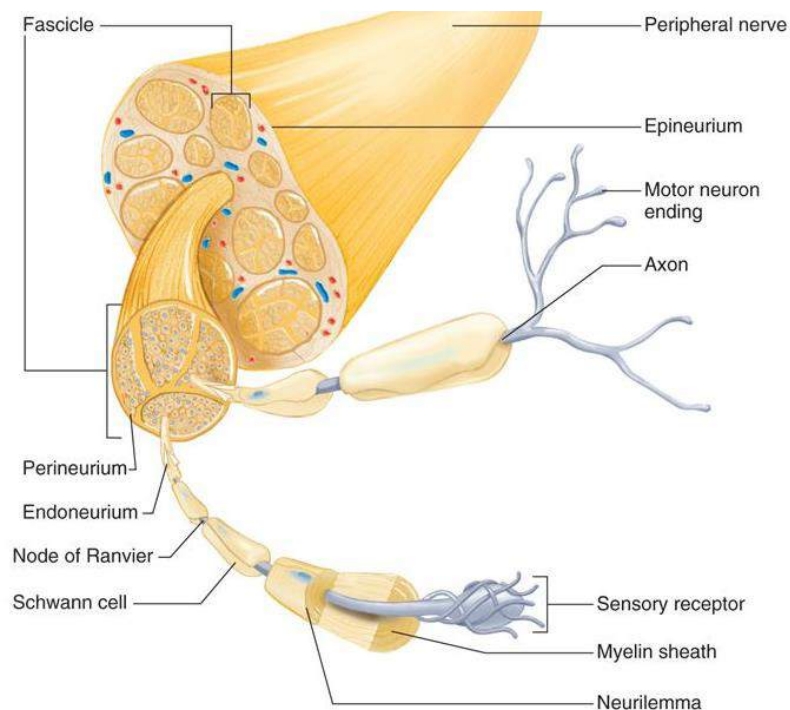
- Greater fascicular
- Neighboring tissue involvement
- Wide excisional margins
- Possible seeding
- Repeat surgical encounters



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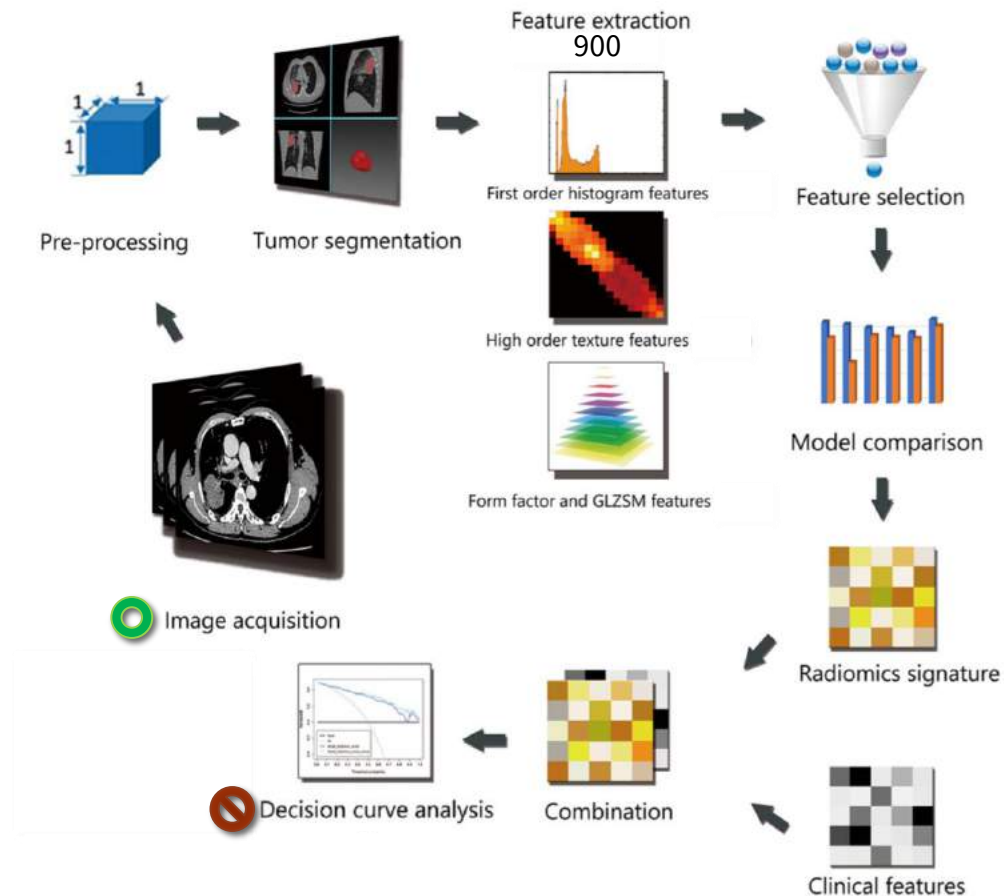
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Workflow

Goal: Identify radiographic imaging features that will correctly classify MPNSTs & Benign PNSTs

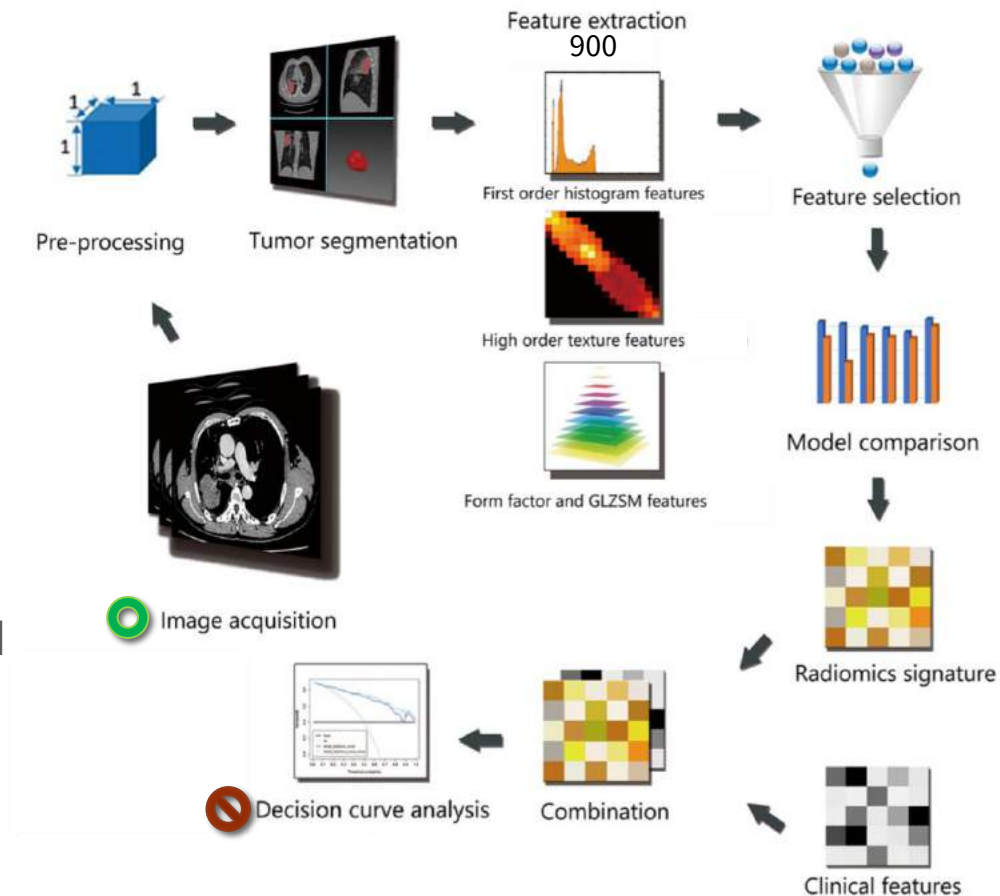
- Imaging Segmentation
- Feature
 - › Extraction
 - › Selection
 - › Optimization
- Prediction Analysis



Workflow

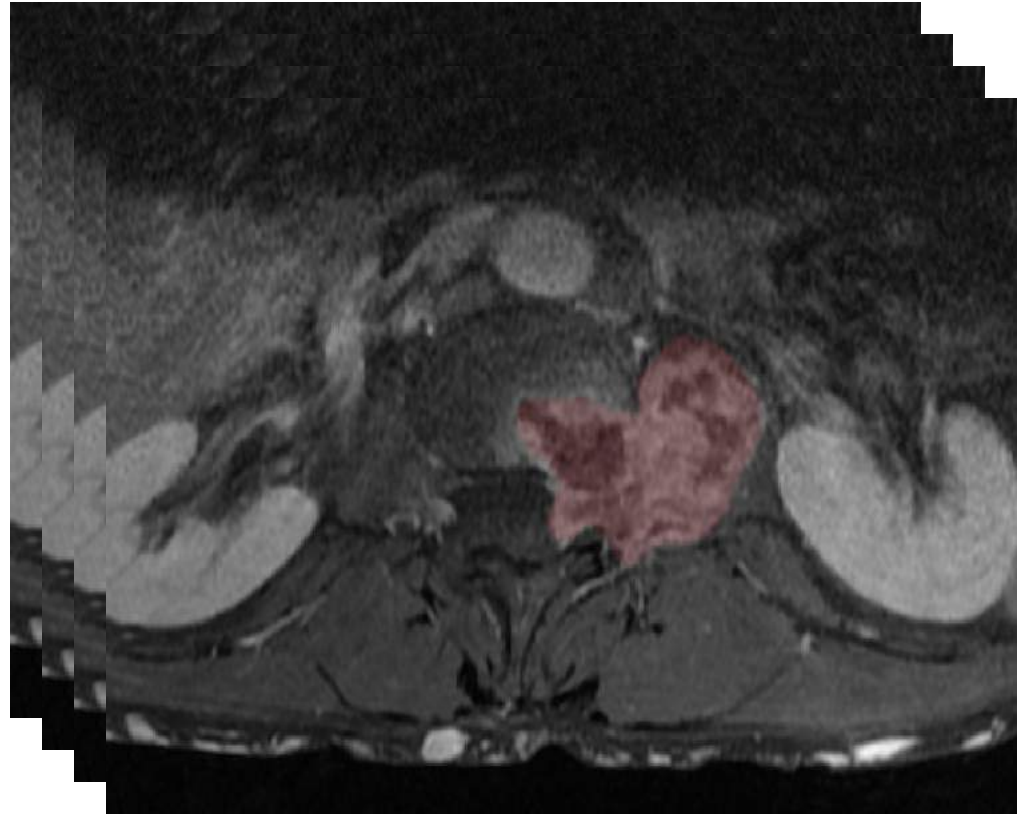
Goal: Identify radiographic imaging features that will correctly classify MPNSTs & Benign PNSTs

- **Input:** MRI T1-gad with Fat Suppression
- **Output:** Classification Label



Workflow

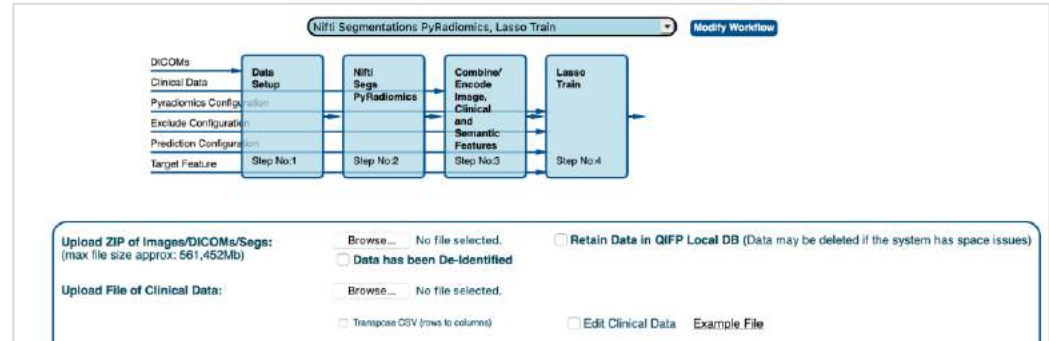
- **Imaging Segmentation**
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Workflow

- Imaging Segmentation
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QIFP: Quantitative Imaging Feature Pipeline



Workflow

1. QIFP Feature Extraction

- 900 features

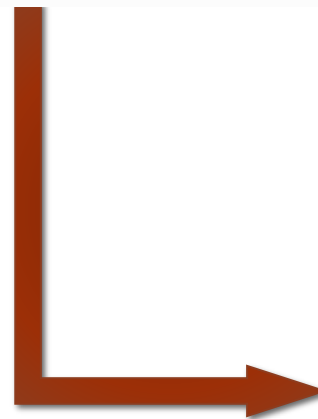
2. QIFP LASSO

- glmnet-package
- 10x Cross Validation

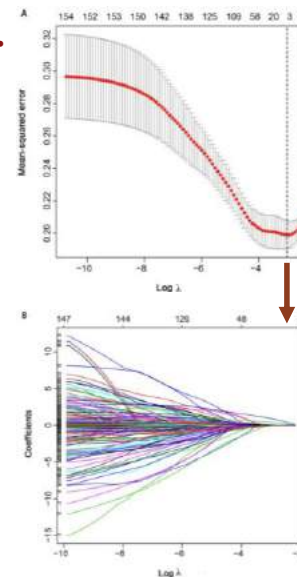
3. QIFP Preliminary model

1.

- First Order Statistics (19 features)
- Shape-based (3D) (16 features)
- Shape-based (2D) (10 features)
- Gray Level Cooccurrence Matrix (24 features)
- Gray Level Run Length Matrix (16 features)
- Gray Level Size Zone Matrix (16 features)
- Neighbouring Gray Tone Difference Matrix (5 features)
- Gray Level Dependence Matrix (14 features)



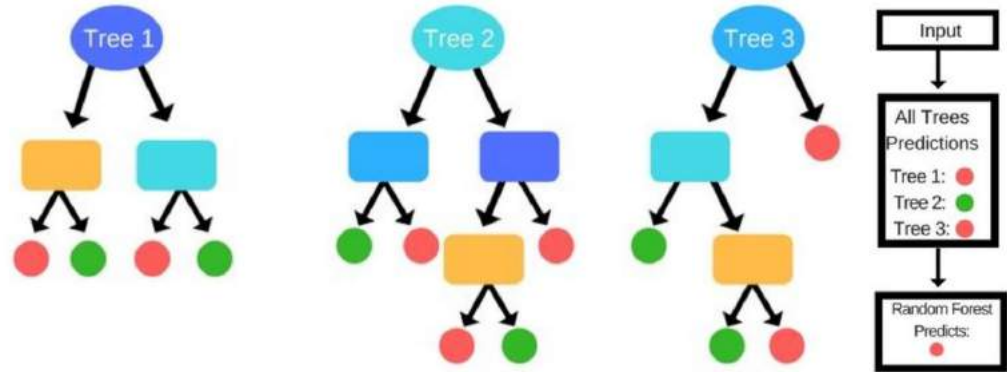
2.



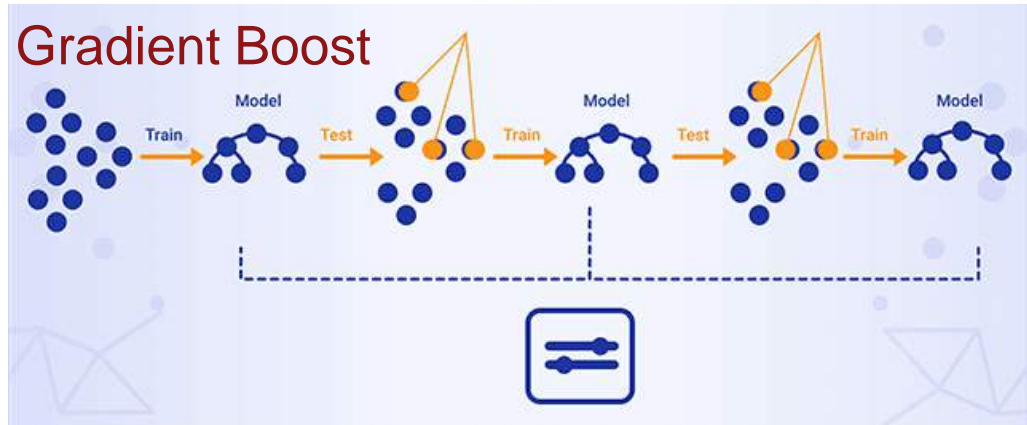
Workflow

- Imaging Segmentation
- Feature
 - › Extraction
 - › Selection
 - › **Optimization**
- Prediction Analysis

Random Forest



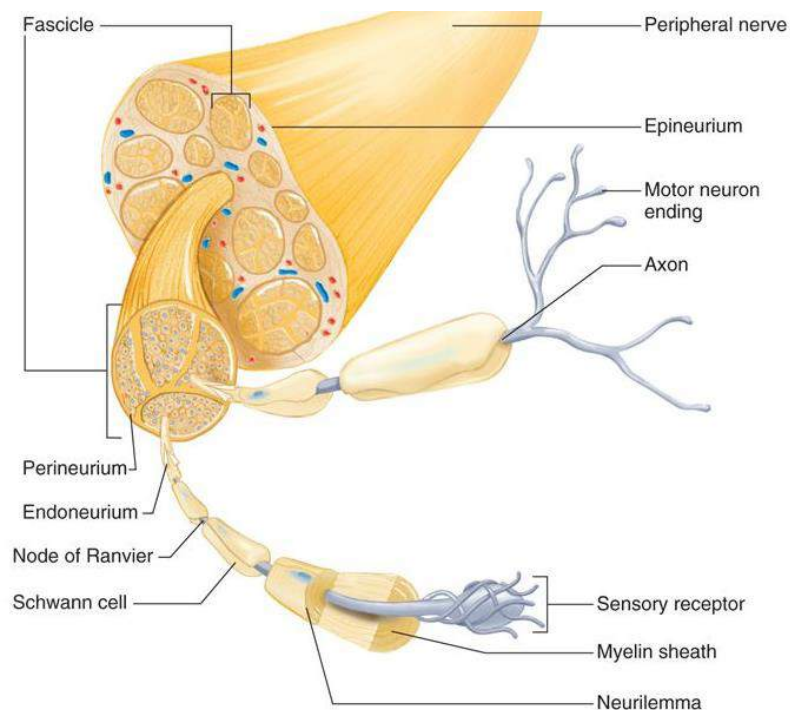
Gradient Boost



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RF and GBM

- **Metrics**
 - Similar values between models
 - Confusion matrix without high “Can’t Miss” population
 - Would benefit from higher N and balanced cohorts
- **Interpretations**
 - Variable Importance ranking is different between models
 - Some features match Radiologists’ methodology
 - Clinical features suggest “pain” is very predictive as well

Future Directions

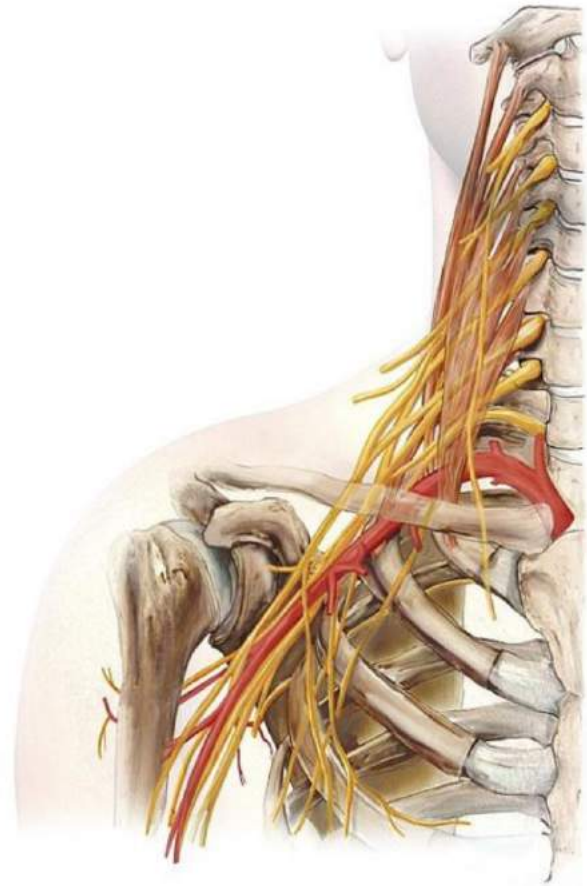
MPNST vs BPNST

- Address imbalance, increase MPNST sampling
- Tuning
 - › LASSO feature selection by multiple seeds and union
 - › GBM n.trees and n.dimensions

Schwannoma vs Neurofibroma

Multinomial - Hybrids

Pediatric Glioblastoma



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