Classification of Malignant & Benign Peripheral Nerve Sheath Tumors

With an Open Source Feature Selection Platform

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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.

**SUV\text{max} \geq 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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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
- Feature
  - Extraction
  - Selection
  - Optimization
- Prediction Analysis
Workflow

- Imaging Segmentation
- Feature
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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
Workflow

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Random Forest

Gradient Boost

Stanford University
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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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