

16725 – Medical Image Analysis – Spring 2018

# TUMOR GRADER

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# THE PROBLEM: TUMOR GRADE

- Tumor grade = Description of a tumor based on how abnormal the tumor cells and tissue look under a microscope
  - Indicator of how malignant or quickly a tumor will spread
  - Undifferentiated cells tend to grow and spread at faster rate than differentiated cell (benign)
- Typically determined via Biopsy
- Grades:
  - Grade I: Well differentiated
  - Grade II: Moderately differentiated
  - Grade III: Poorly differentiated
  - Grade IV: Undifferentiated



# PROJECT: TUMOR GRADER

**Goal:** To assess the grade of brain tumors through multimodal MRI Images

**Importance:** Eliminate the need for biopsy, help plan treatment, and determine patient prognosis

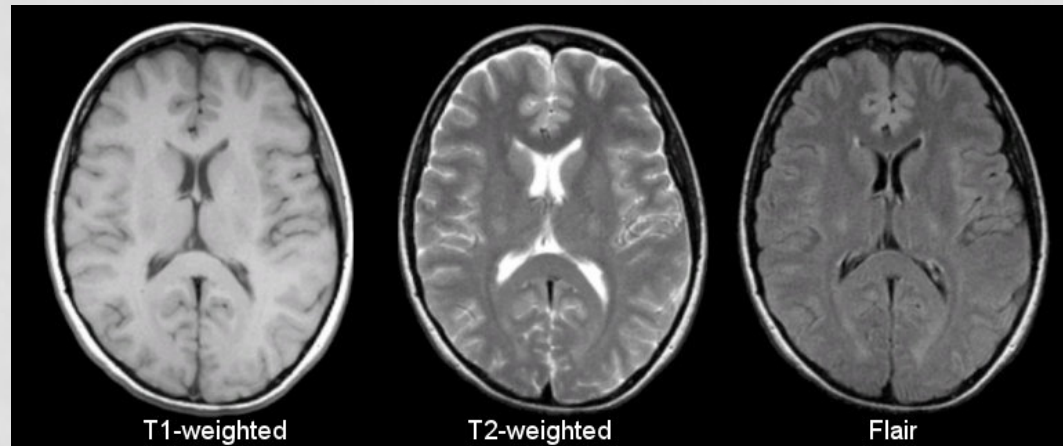
**Challenge:** Using radiological imaging to substitute histology

# BRAIN MRI DATASET: REMBRANDT

- The Repository of Molecular Brain Neoplasia Data (REMBRANDT) contains pre-surgical magnetic resonance (MR) multi-sequence images from 130 patients
- Clinical data
  - Tumor Grade: II, III, IV
  - Tumor Type: Astrocytoma, oligodendroglioma, or Glioblastoma (basically Astrocytoma IV)
- 30 MRI Features evaluated by 3 radiologists
  - Picked the radiologist with the most conservative approach

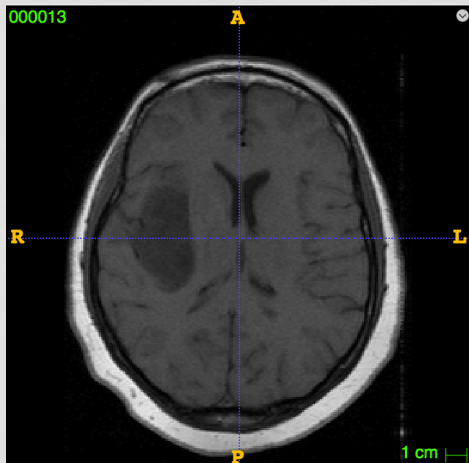
# MRI TYPES

- 3 types:
  - T1-Weighted – fat brightest, then white matter, gray matter, and CSF
  - T2-Weighted – CSF brightest, then gray matter, white matter, muscles
  - Flair – suppress bright CSF signal, best detection of small lesions/inflammations, then fat, grey matter, white matter, and CSF

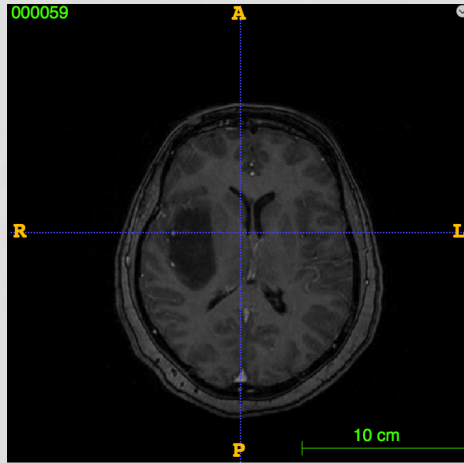


	Repetition Time (msec)	Time of Echo (msec)
T1-Weighted (short TR and TE)	500	14
T2-Weighted (long TR and TE)	5000	90
Flair (very long TR, TE)	9000	114

# PRELIMINARY EXAMINATION

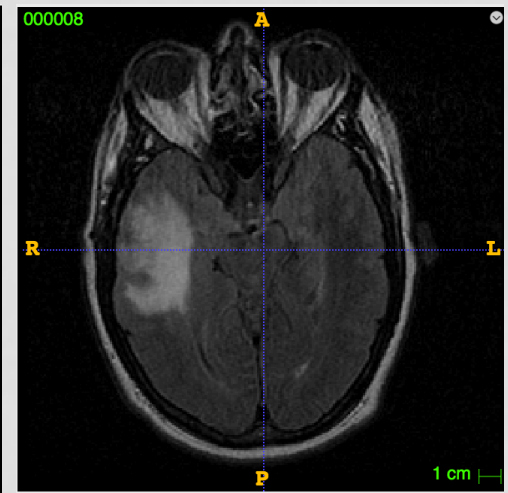
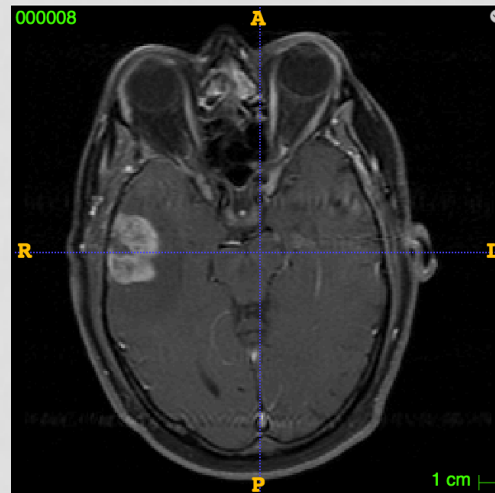


Astrocytoma II



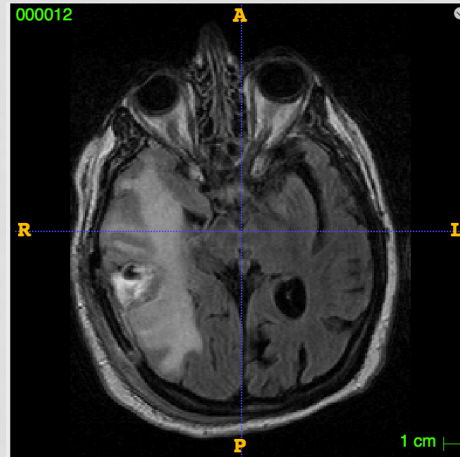
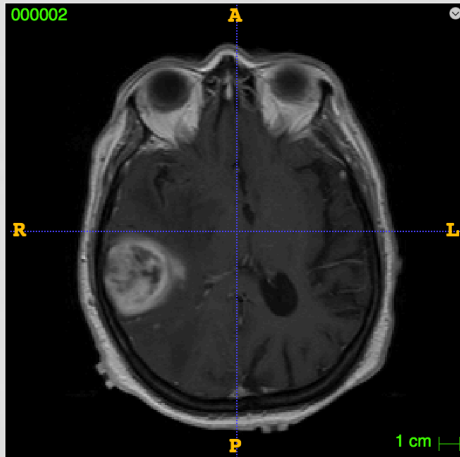
- Tumor border more defined in T1-weighted MRI
- Astrocytoma II is darker, typically less dense than surrounding tissue

- Astrocytoma III appears more defined - with condensed and less dense area
- Edema - the whiteness on T2-weighted and FLAIR MRI



Astrocytoma III

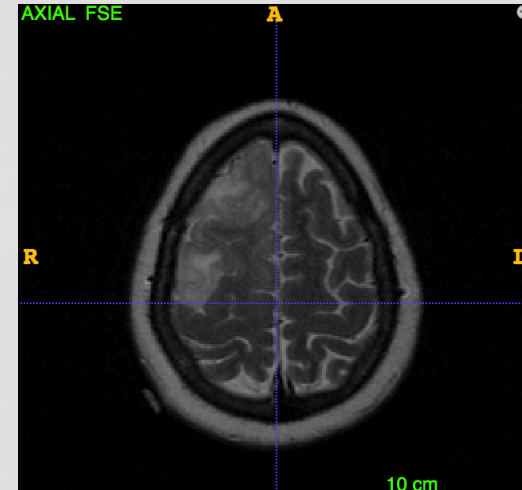
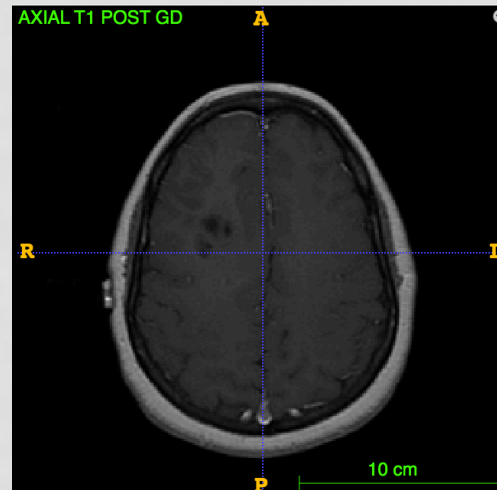
# PRELIMINARY EXAMINATION



- Glioblastoma (Astrocytoma) looks very severe
- Well-defined tumor borders
- Wide spread of Edema

Glioblastoma

- Oligodendroglioma characteristics less defined



Oligodendroglioma II



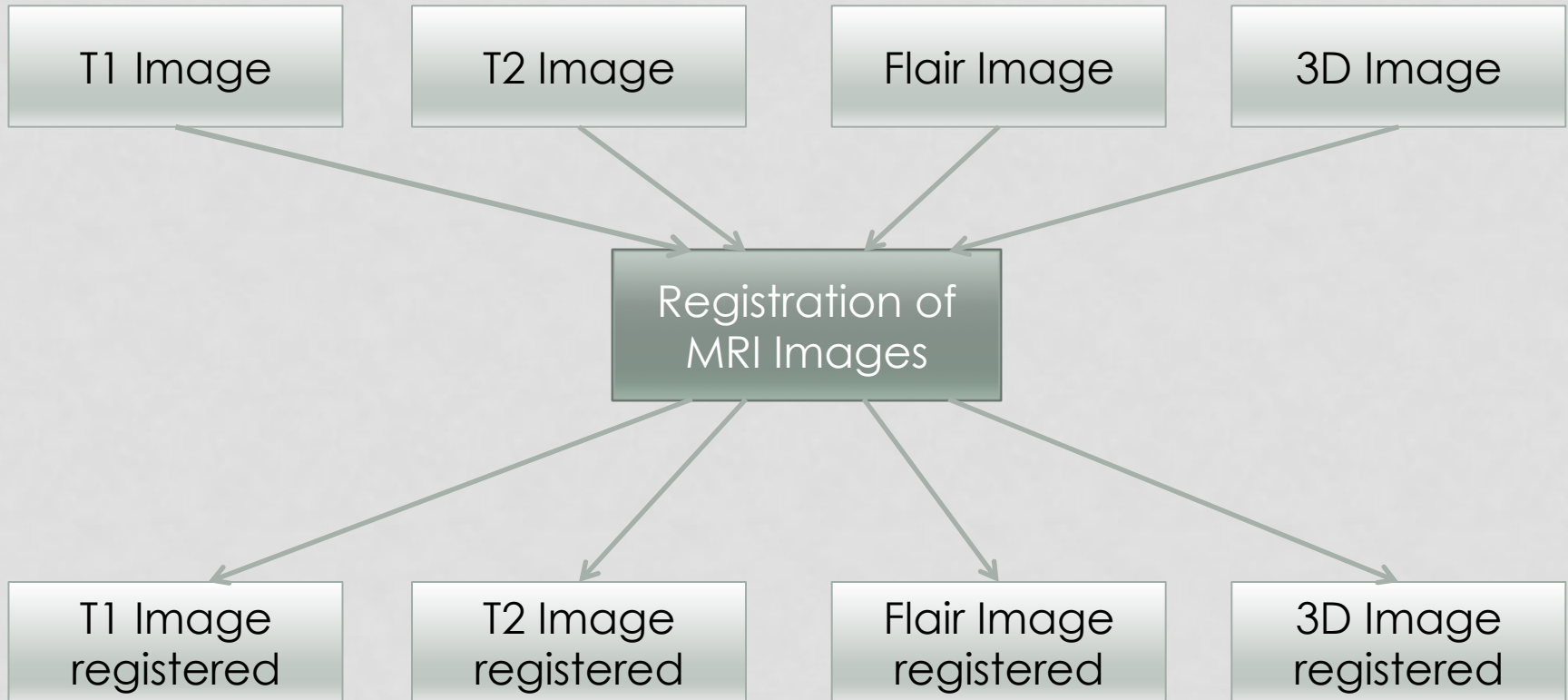
# CLASSIFICATION

- Bayesian Network - preliminary analysis
  - 30 features, 30 instances
  - 10-fold cross-validation
  - Accuracy: 63.333%, kappa: -0.0543
- Correlation attribute evaluation
  - Top ranked attributes include:
    - Proportion of Edema
    - Extent resection of vasogenic edema
    - Edema crosses midline
    - Proportion of enhancing and non-enhancing tumor
    - Definition of enhancing and non-enhancing margins
    - Side of tumor epicenter

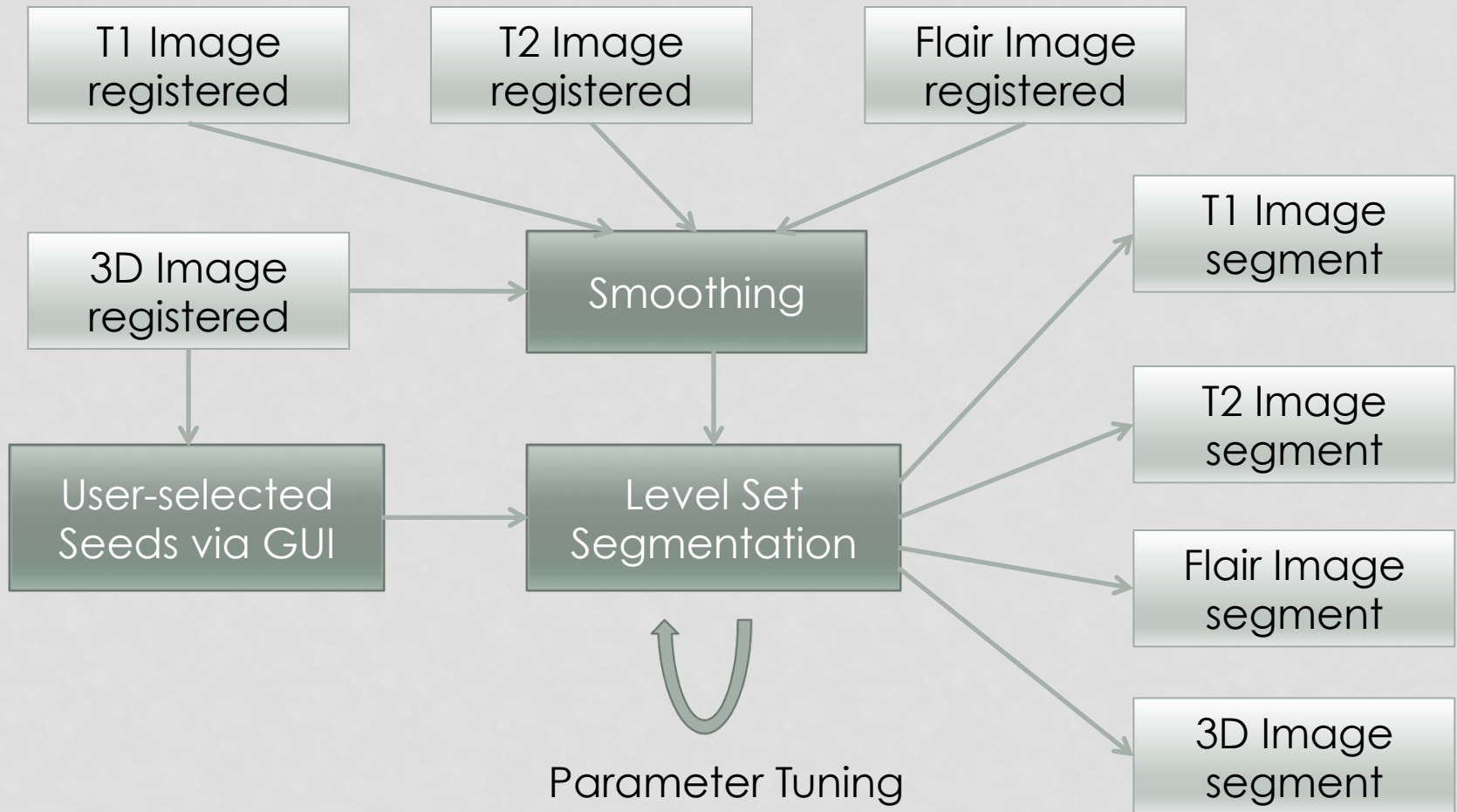
Ranked attributes:		
0.4181	10	f9
0.3987	15	f14
0.3624	29	f28
0.3084	16	f15
0.2752	7	f6
0.274	25	f24
0.2251	19	f18
0.21	20	f19
0.1719	14	f13
0.1542	3	f2
0.1421	28	f27
0.1414	23	f22
0.1411	5	f4
0.1366	27	f26
0.1358	18	f17
0.1245	13	f12
0.1196	6	f5
0.1136	8	f7
0.0858	12	f11
0.0858	17	f16
0.0822	2	f1
0.0822	30	f29
0.0661	11	f10
0.0642	24	f23
0.0629	26	f25
0.061	31	f30
0.0579	22	f21



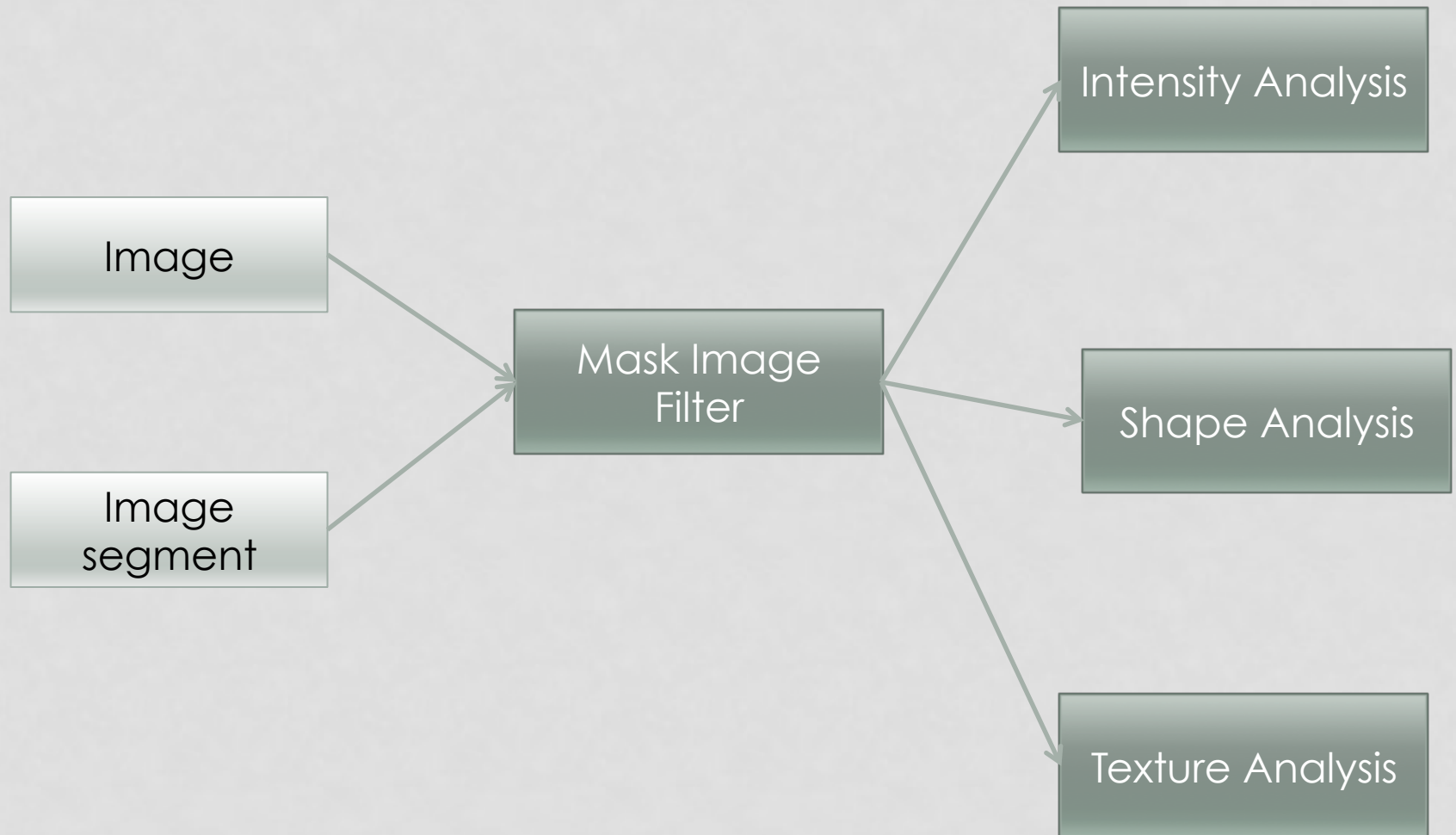
# OVERVIEW OF APPROACH



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## Feature Space

Intensity Analysis

Location

Contour Analysis

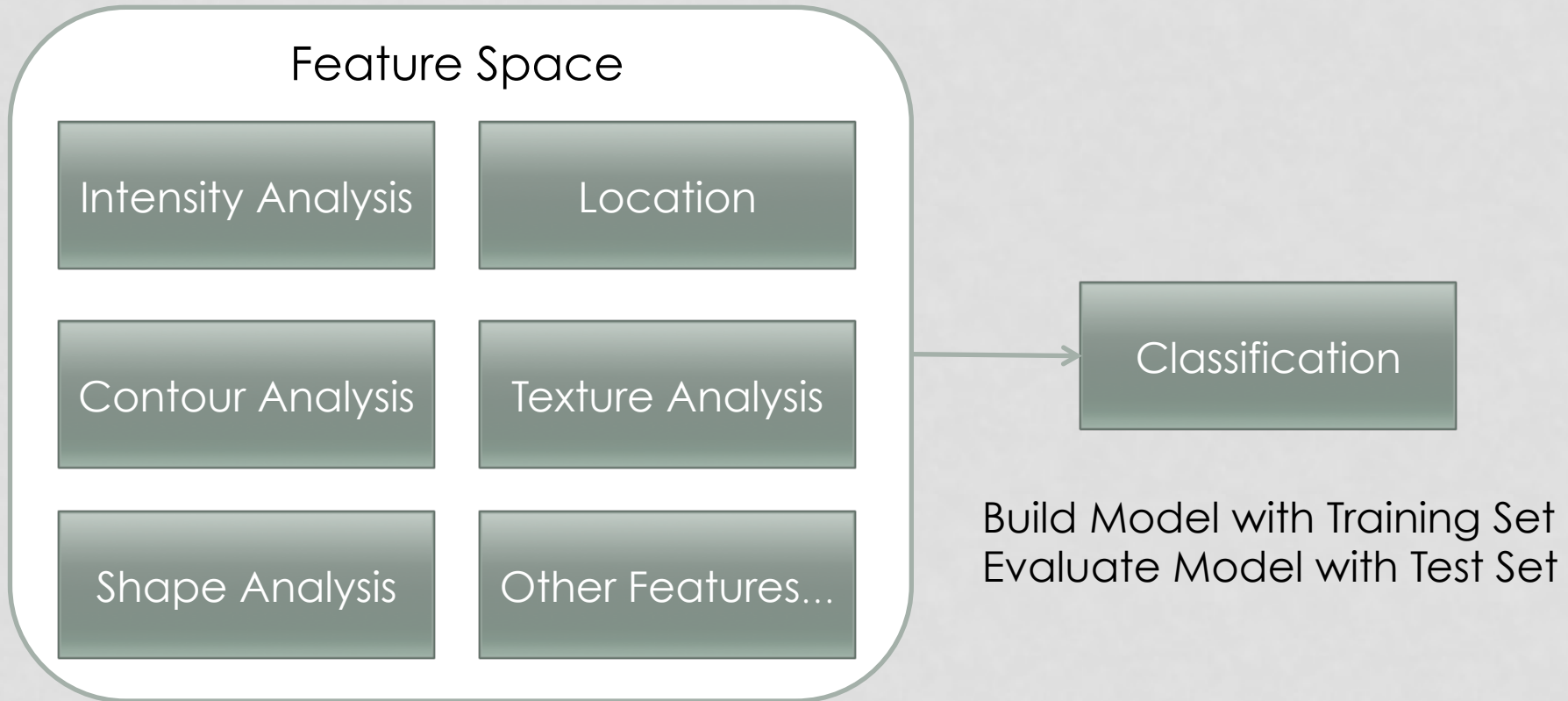
Texture Analysis

Shape Analysis

Other Features...

Classification

Build Model with Training Set  
Evaluate Model with Test Set



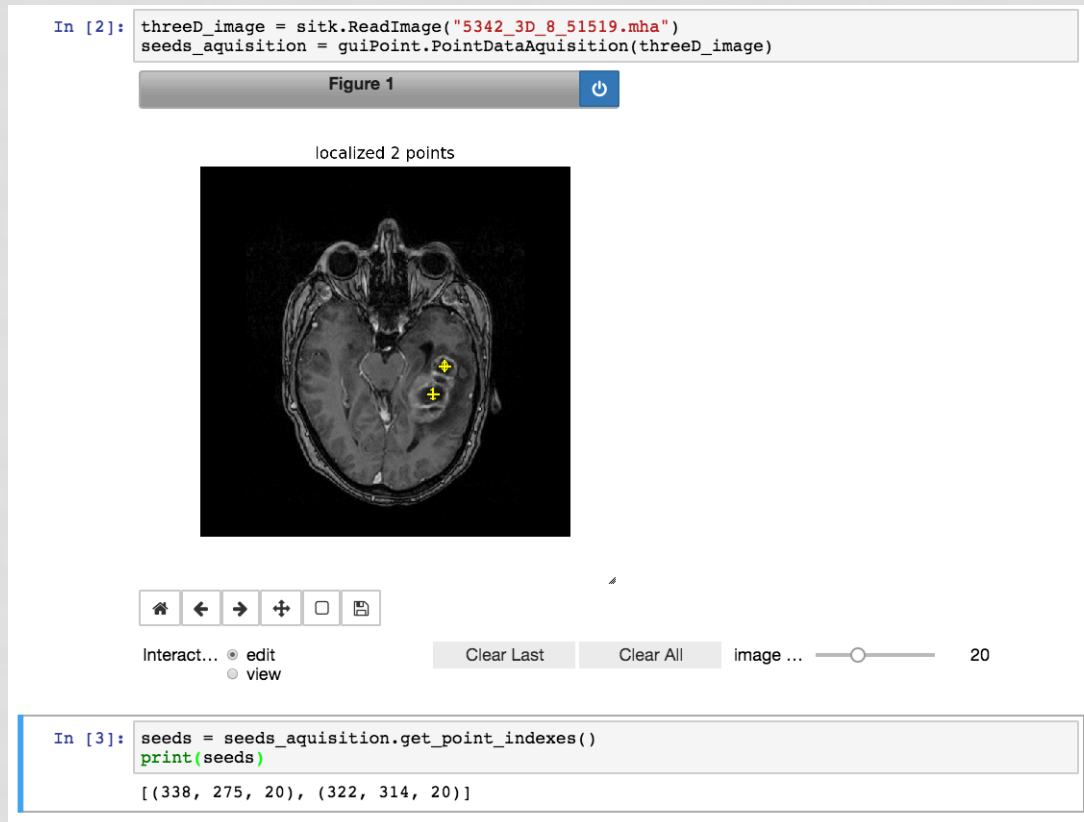
# FEATURE EXTRACTION WITH ITK/SITK FILTERS

- Registration → ImageRegistrationMethod()
- Smoothing → CurvatureFlowImageFilter()
- Level Set Segmentation
  - CurvesLevelSetImageFilter()
  - FastMarchingImageFilter()
  - ShapeDetectionLevelSetImageFilter()
- Other Segmentation methods
  - confidenceconnectedimagefilter()
- MaskImageFilter

# FEATURE EXTRACTION WITH ITK/SITK FILTERS

- BinaryImageToLabelMapFilter()
- Intensity analysis → LabelIntensityStatisticsImageFilter
  - Kurtosis, Mean, max, min, variance...
- Shape analysis → LabelShapeStatisticsImageFilter()
  - Perimeter
  - Flatness
  - Roundness
  - Diameter
  - ...
- Texture Analysis → ScalarImageToTextureFeaturesFilter()
  - Entropy
  - Energy
  - Intertia
  - ...

# PRELIMINARY RESULTS – GUI TOOL

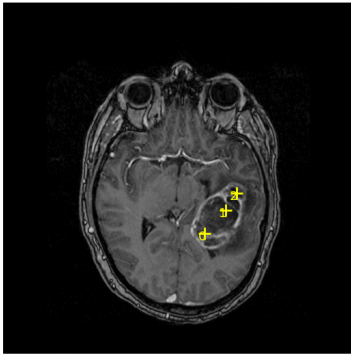


GUI for obtaining seeds for segmentation

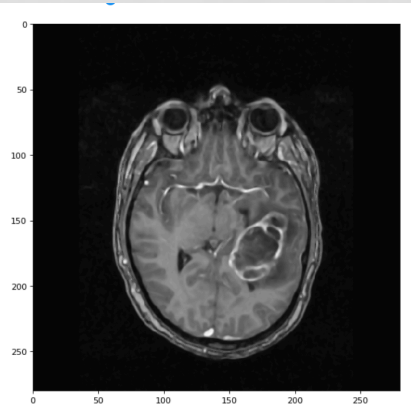


# PRELIMINARY RESULTS

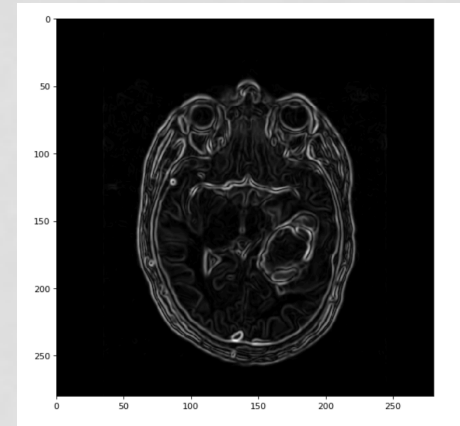
localized 3 points



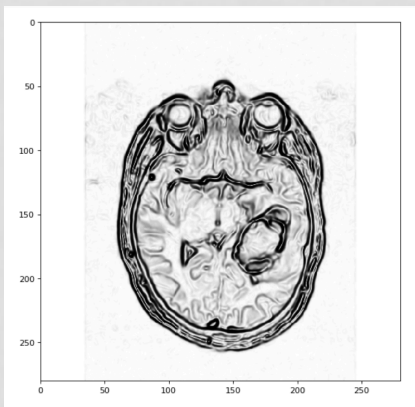
Select Points



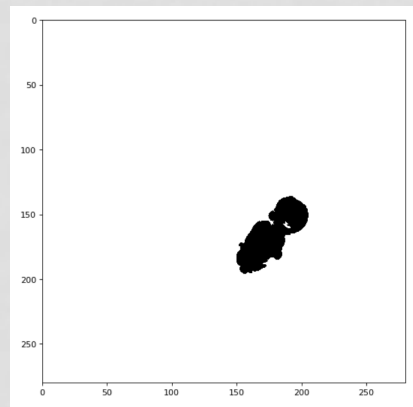
Curvature Flow Filter



Gradient Magnitude  
Recursive Gaussian

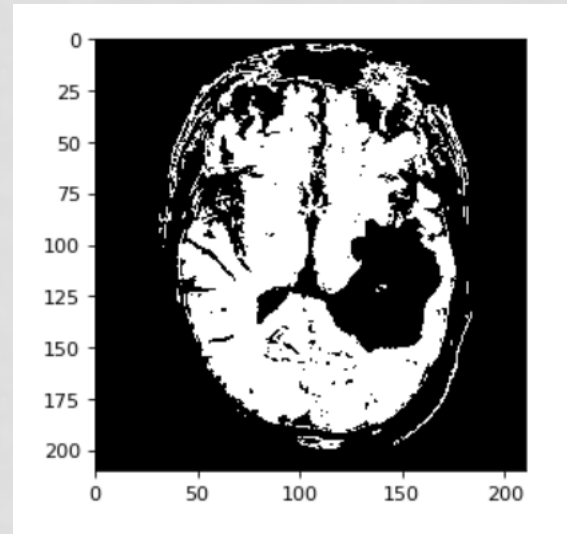
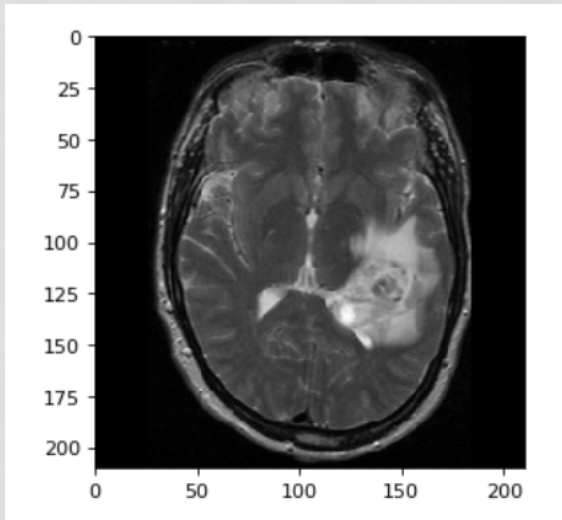


Sigmoid



Tumor Segment

# PRELIMINARY RESULTS



Confidence connected Image filter for T2-weighted MRI

**Main Challenge:** Tumor Segmentation

# REFERENCES

- <https://www.cancer.gov/about-cancer/diagnosis-staging/prognosis/tumor-grade-fact-sheet>
- <http://casemed.case.edu/clerkships/neurology/Web%20Neurorad/MRI%20Basics.htm>
- Zacharaki, E. I., Wang, S., Chawla, S., Soo Yoo, D., Wolf, R., Melhem, E. R., & Davatzikos, C. (2009). Classification of brain tumor type and grade using MRI texture and shape in a machine learning scheme. *Magnetic resonance in medicine*, 62(6), 1609-1618.