Automated diagnosis of Autism Spectrum Disorder condition using shape based features extracted from brainstem

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Autism Spectrum Disorder (ASD)

- Neurodevelopmental Disorder
- Characterized by significant challenges in
  - Social Interaction
  - Communication
  - Repetitive patterns of behavior

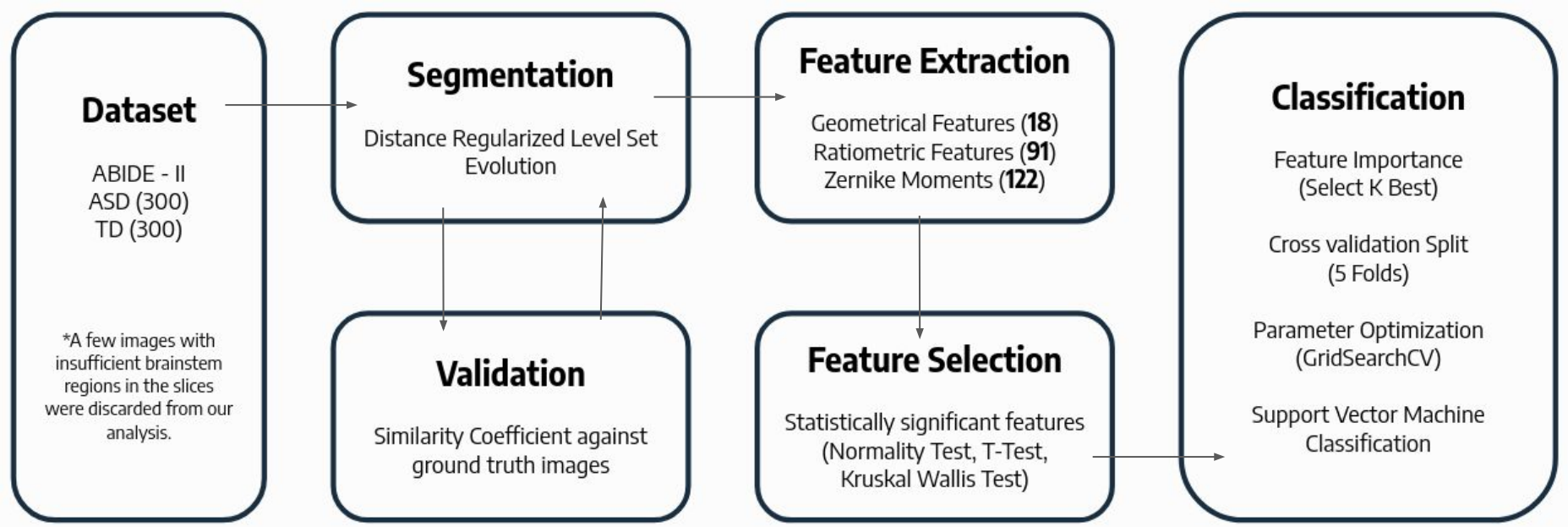
- Mainly controlled by brainstem region

- Anatomical differences in the Brainstem act as an essential biomarker for ASD

Need for diagnostic tool

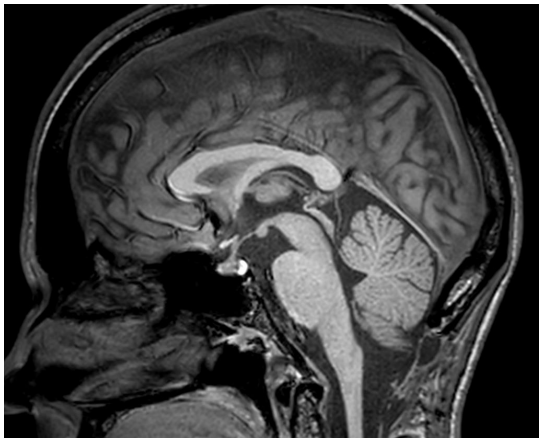
- Observational assessment
  - medical evaluation,
  - cognitive or developmental testing,
  - language testing,
  - interview of the caregiver
    - medical
    - developmental history
    - report of current behavior and abilities
- Due to its time consuming nature, along with absence of any notable discriminator, the diagnosis of ASD is often delayed.
- Prevents patients from receiving proper and timely interventive care.

Proposed Methodology



Dataset

- Autism Brain Image Data Exchange (ABIDE-I, ABIDE-II)
- Structural Magnetic Resonance Imaging (sMRI)
- Mid-sagittal view slices considered
- Classes:
  - Typically developing (TD)
  - Autism Spectrum Disorder (ASD)
- 300 images considered from each class



https://fcon_1000.projects.nitrc.org/indi/abide/

Brain-stem Segmentation

- Distance-Regularised Level Set (DRLSE) method used

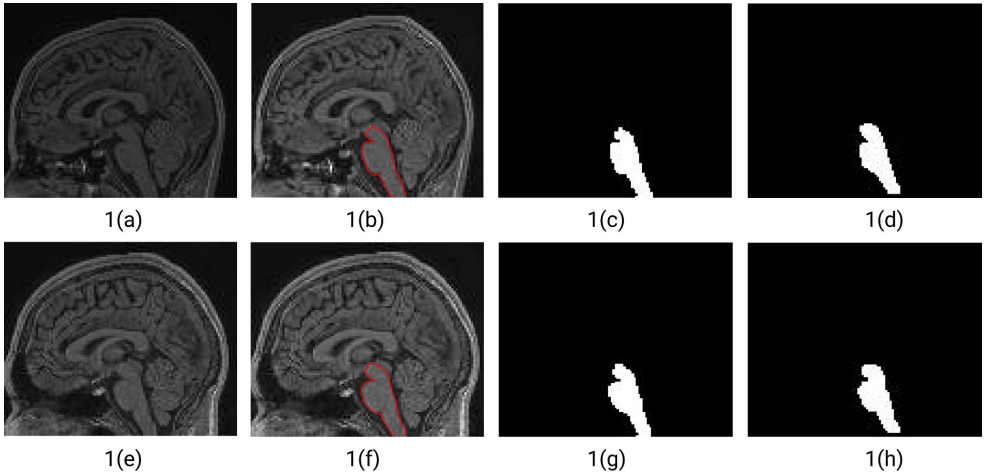
$$\frac{\delta f}{\delta t} = \mu\left(\mathrm{div}_p(|\nabla f|)\right) + \lambda\delta(f)\left(g\frac{\nabla f}{|\nabla f|}\right) + \alpha g\delta(f)$$

- Gradient flow equation solved
  - g = gaussian gradient used for edge detection (to avoid leakage of contours)
  - α=1
  - μ=0.2
  - λ=0.1
  - number of iterations = 15.
  - Values set empirically.

Brain-stem Segmentation

Similarity measure results:

- Pearson and Heron II (PH II)
  - mean correlation = 0.9740
- Sokal and Sneath II (SS II)
  - mean correlation = 0.9727



(a, e) Brain Image ASD, TD; corresponding (b, f) Final DRLSE evolved contour;
(c, g) Masked brainstem; (d, h) Ground truth binary image of brainstem

Feature Extraction

- Geometric features (18)
  - area
  - perimeter
  - eccentricity
  - orientation
  - bounding boxes, etc.

- Ratio-metric features (91)

- Zernike moments (122)
  - Various orders and degrees
  - Amplitude (61), Phase (61)

Feature Selection

1. Normality Test

2. t-Test (normal distribution)

3. Kruskal-Wallis Test (non-normal distribution)

4. SelectKBest method (scikit-learn library)
    a. Ranks based on F-test

Feature Selection

- 59 geometric features significant
  - Eccentricity/Perimeter (ratio-metric)
  - Area/Perimeter (ratio-metric)
  - Minor Axis Length
  - Centroid2/Convex Area (ratio-metric)
  - Convex Area
- 32 Zernike moments significant
  - n 7 m 3 A_{OH}
  - n 12 m 8 A_{OH}
  - n 17 m 7 A_{OH}
  - n 7 m 3 A_{OH}
  - n 7 m 3 A_{OH}

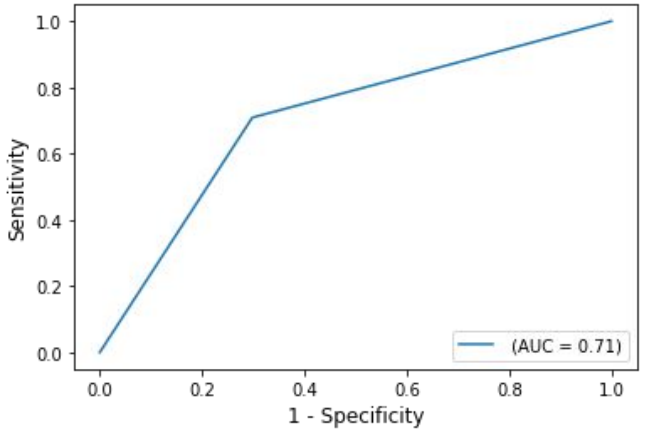
Classification

Linear Kernel	58.92%
Polynomial Kernel	57.39%
Sigmoidal Kernel	**70.53%**
RBF Kernel	60%

- Support Vector Machine (SVM) classifier used with different kernels
- Sigmoidal kernel gives best results
- 4 folds for training, 1 fold for testing

Classification

- Accuracy: 0.7053
- Sensitivity: 0.6964
- Specificity: 0.7142
- F1 Score: 0.7027
- Area Under Curve: 0.71



ROC-AUC Curve