Mental Illness Recognition Through Neuroimaging and Deep Learning

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Background [1]-[6]

Current diagnoses use DSM-V & ICD-10

Poor understanding of biological mechanisms

- Clinical observation vs. Pathology → Reliance on clinician discretion
- Potentially invalid criteria → Over and under specificity; Symptom overlap between disorders; Heterogeneity

Psychotic Spectrum Disorders [7]-[9]

Psychosis: symptom of psychiatric condition (primary) or underlying disease (secondary)

Primary Psychosis: Schizophrenia, Schizoaffective Disorder, Schizophreniform Disorder, Brief Psychotic Disorder, Delusional Disorder, Bipolar Disorder, Major Depressive Disorder, Post-traumatic Stress Disorder

Overlapping Symptoms

PANSS Subscales

Positive	Negative
P1. Delusions	N1. Blunted affect
P2. Conceptual disorganization	N2. Poor rapport
P3. Hallucinatory behavior	N3. Poor Rapport
P4. Excitement	N4. Passive/apathetic social withdrawal
P5. Grandiosity	N5. Difficulty in Abstract Thinking
P6 Suspiciousness	N6. Lack of spontaneity and flow in conversations
P7. Hostility	N7. Stereotyped thinking

Research Questions

- Can we identify biomarkers corresponding to mental illness?
- Can we identify biomarkers corresponding to symptoms?
- What is the relationship between biomarkers associated with disorders and those associated with symptoms?

Approach

Data Inputs

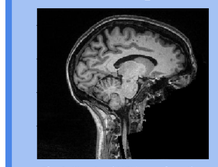


Fig. 1. Structural MRI image from the UCLA Consortium.

Sources	NIMH Data Archive (NDA) UCLA Consortium for Neuropsychiatric Phenomics
Scan Type	T1-weighted, anonymized, defaced structural MRI
Symptom data	Positive and Negative Syndrome Scale (PANSS), a diagnostic questionnaire

Model Framework

WHY ML?	Use machine learning to identify patterns in large, complex MRI data
DESIGN	VoxResNet Encoder with Deformable 3D Convolutions and added Triplet Loss

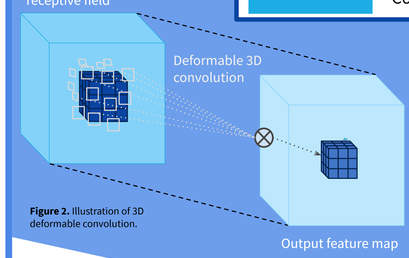


Figure 2. Illustration of 3D deformable convolution.

Figure 3. Illustration of triplet loss. [10]

Model Training

Use models built on the same backbone and train on different data

Model(s) **learning** the **regions of the brain** associated with specific **mental disorders**

Disorder labels ← MRI Images → Symptom labels

Model(s) **learning** the **regions of the brain** associated with specific **symptoms** patients experience

Analysis

1	2	3
Compare and contrast the differing **areas of attention** to find **overlapping biomarkers** for symptoms that typically occur with specific disorders and those that share areas of attention	Combine models for use in simultaneous detailed multi-symptom and multi-disorder classification	Use embeddings generated by models to view MRI data in a new feature space to show how distinct labels relate

Results

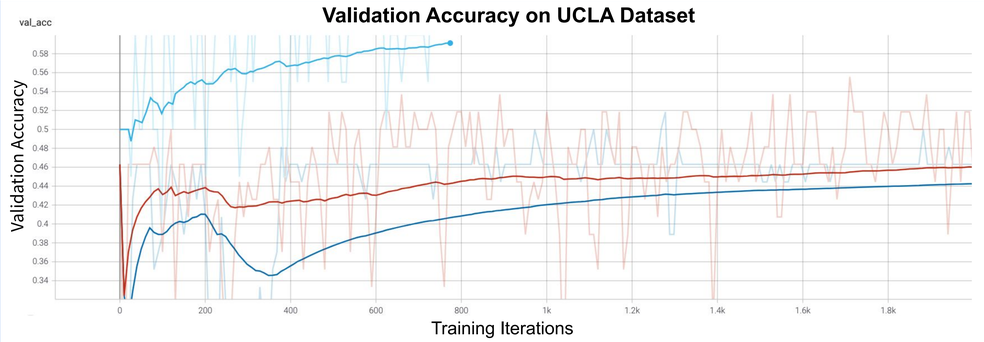
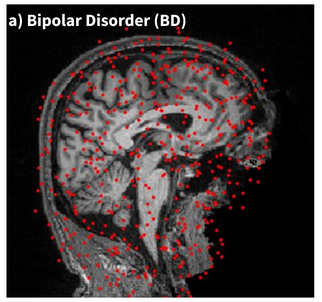


Figure. 4. Validation accuracy comparison between three experiments

- 59% performance on classification of Schizophrenia vs Bipolar (Light blue)
- 46% performance on multiclass classification (between healthy, schizophrenic, bipolar, and ADHD individuals) (Orange)
- 44% performance on multiclass classification with added triplet loss (Dark blue)



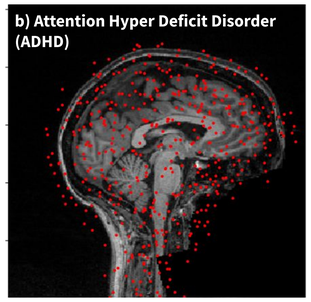
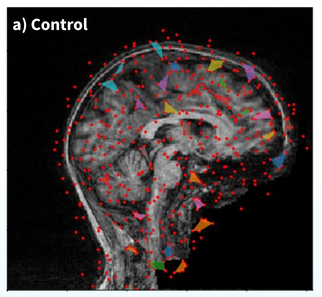


Figure 5. Visualization of learned offsets from supervised model from a) a patient with bipolar disorder, and b) a patient with ADHD. Red dots indicate the voxels of greatest deformation the model sampled when predicting diagnosis. The data used for this was from the UCLA Consortium dataset which included Control, ADHD, SCZ, and BD MRI scans.



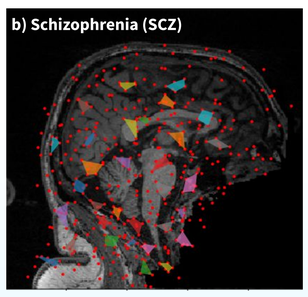


Figure 6. Further clusterings of offset points on structural MRI from a) a healthy control, and b) a patient with schizophrenia. The colored areas indicate regions of points which were closer to than to all other points each other than other points. This potentially indicates areas of greatest interest to the model and thus be possible biomarkers.

Future Work

- Incorporate multiple datasets to train model from NDA
- Move analysis to include functional MRI images and inspect how they differ from the anatomical MRI
- Develop unsupervised model that clusters scans based on deep features without information about diagnosis or symptoms
- Compare symptoms across different diseases

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