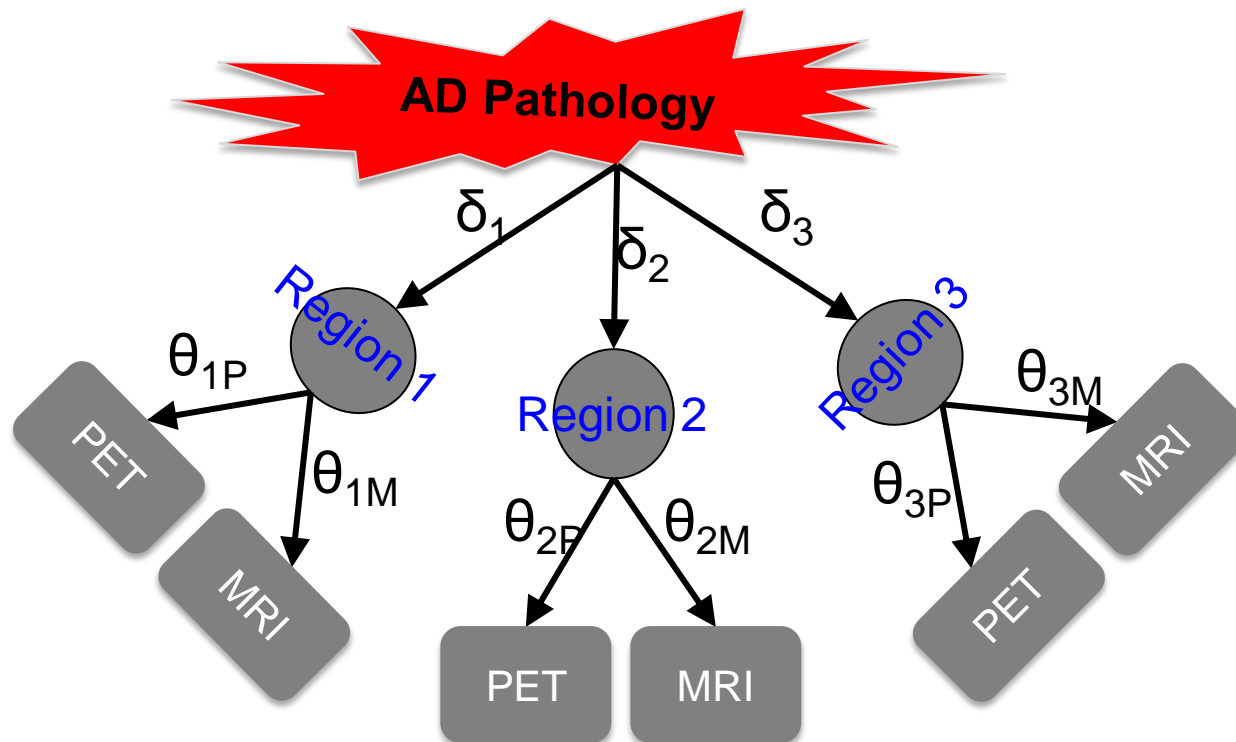


Identifying Alzheimer's Disease Brain Regions from Multi-Modality Neuroimaging Data Using Sparse Composite Linear Discrimination Analysis (SCLDA)

Shuai Huang, Jing Li, Jieping Ye, Teresa Wu, Kewei Chen, Adam Fleisher, Eric Reiman

A tree structure which links the AD pathology, brain regions, PET and MRI



MRI and PET measure the same AD pathology, and supplement each other

A joint analysis of MRI and PET imaging data will increase the statistical power to detect AD-related brain regions

- δ_1 : the relatedness of brain region 1 with the AD pathology
- θ_{1P} : the signal strength of θ_1 reflected on PET (i.e., enhanced or reduced)
- θ_{2M} : the signal strength of θ_1 reflected on MRI (i.e., enhanced or reduced)

Original formulation – impose penalty on both θ and γ

$$\hat{\Theta} = \operatorname{argmin}_{\Theta} l_1(\Theta | \{\mathbf{Z}^{(1)}, \mathbf{Z}^{(2)}, \dots, \mathbf{Z}^{(M)}\}) = \operatorname{argmin}_{\Theta} \left\{ -l_0(\Theta | \{\mathbf{Z}^{(1)}, \mathbf{Z}^{(2)}, \dots, \mathbf{Z}^{(M)}\}) + \lambda_1 \sum_k \delta_k + \lambda_2 \sum_{k,l,m} \gamma_{k,l}^{(m)} \right\}, \text{ subject to}$$

$$\theta_{k,l}^{(m)} = \delta_k \gamma_{k,l}^{(m)}, \delta_k \geq 0, 1 \leq k, l \leq p, 1 \leq m \leq M.$$

Reduced formulation – a non-convex sparse learning model

$$\tilde{\Theta} = \operatorname{argmin}_{\Theta} l_2(\Theta | \{\mathbf{Z}^{(1)}, \mathbf{Z}^{(2)}, \dots, \mathbf{Z}^{(M)}\})$$

$$= \operatorname{argmin}_{\Theta} \left\{ -l_0(\Theta | \{\mathbf{Z}^{(1)}, \mathbf{Z}^{(2)}, \dots, \mathbf{Z}^{(M)}\}) + \lambda \sum_k \sqrt{\sum_{l=1}^q \sum_{m=1}^M |\theta_{k,l}^{(m)}|} \right\}$$

Superiority over L1/L2 penalty

Less shrinkage effect – less irrelevant features been selected

No more “all-in-all-out” solution for the parameters under the same square root

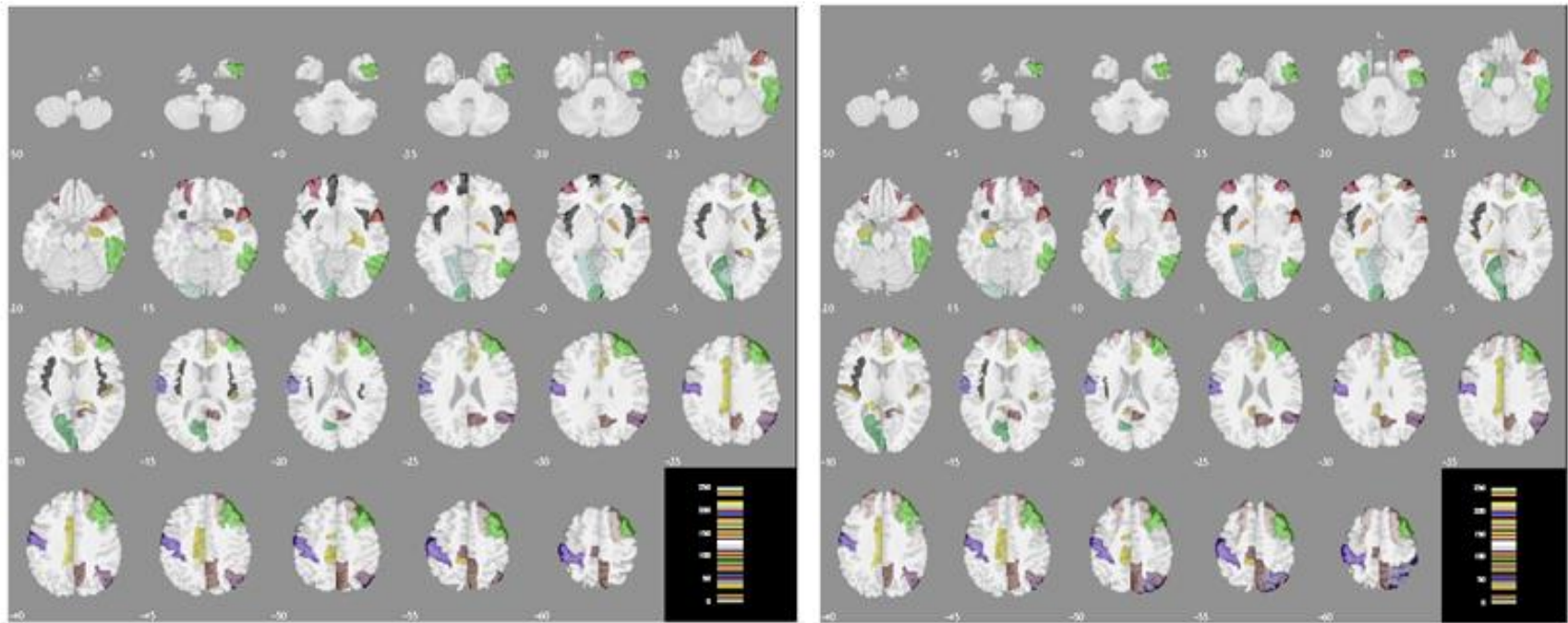
DC (difference of convex functions) programming is used to solve the optimization task

Has a linkage with adaptive LASSO

Locations of AD-related brain regions

PET

MRI



Most of the AD-related regions are consistent with existing knowledge