Large-Scale Unsupervised Deep Representation Learning for Brain Structure

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Outline

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Data

Data Preprocessing

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- We downsample all the images to 100 by 100 by 100 dimensions to reduce the memory requirement

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Deep Representation Learning Models

Convolutional Autoencoders

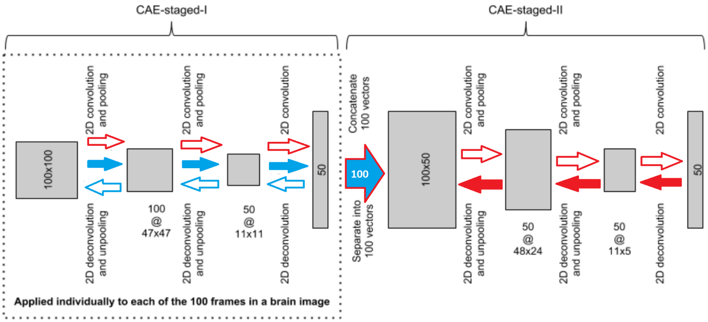
- An autoencoder (AE) is a neural network composed of an *encoder* – transforms data into its vector representation – and a *decoder* – reconstructs data from its encoding
- Minimize loss between original image and reconstruction
- Capture frequently occurring features through parameter sharing form input to convolution and deconvolution layers

- Maxpooling/Unpooling
- Rectified Linear Activation
- Batch Normalization

Deep Representation Learning Models

Convolutional Autoencoders

CAE Staged



Deep Representation Learning Models

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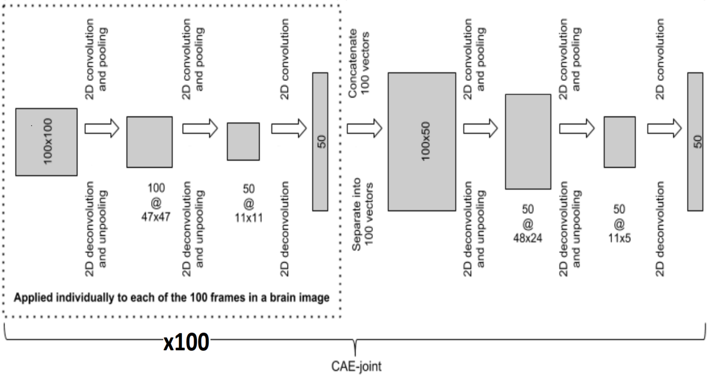
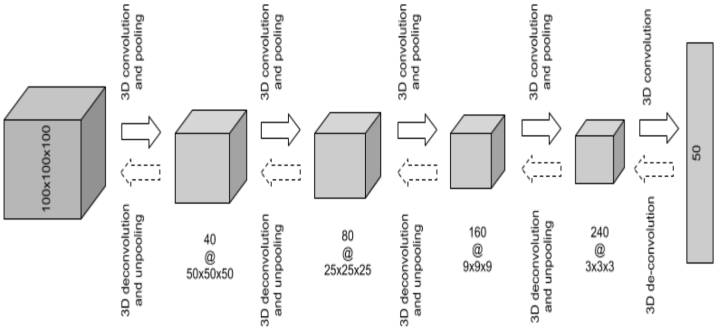
CAE Joint



Deep Representation Learning Models

Convolutional Autoencoders

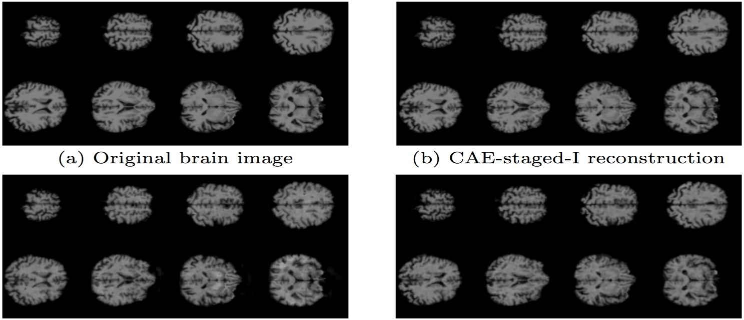
CAE 3D



Deep Representation Learning Models

Convolutional Autoencoders

Reconstructions



(a) Original brain image

(b) CAE-staged-I reconstruction

(c) CAE-joint reconstruction

(d) CAE-3D reconstruction

Fig. 3: 2D frames in original and reconstructed brain images.

Outline

Experimental Evaluation

Qualitative Analysis

- Effect of voxel's perturbation on node's activation
- Saliency map indicating which voxels present important activation regions for each node

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Qualitative Analysis

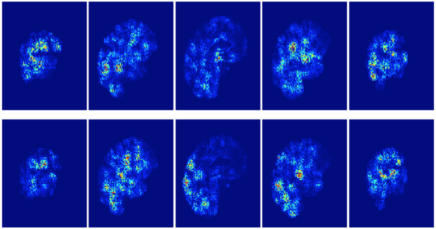

Fig. 4: Saliency map of two nodes in the embedding layer - CAE-staged

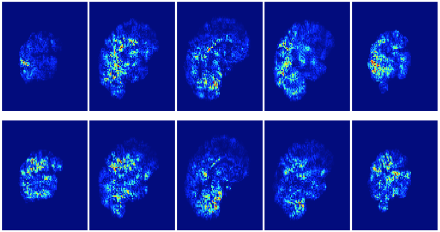

Fig. 5: Saliency map of two nodes in the embedding layer - CAE-joint

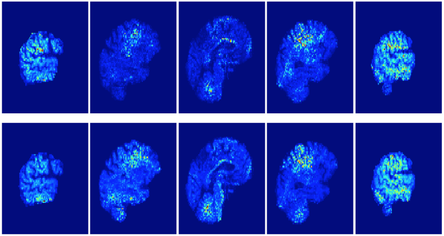

Fig. 6: Saliency map of two nodes in the embedding layer - CAE-3D

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Experimental Evaluation

Quantitative Analysis

Quantitative Analysis

	Logistic Regression				Random Forest			
Classification	**FS**	**CAES**	**CAEJ**	**CAE-3D**	**FS**	**CAES**	**CAEJ**	**CAE-3D**
H-ADNI / AD	0.81	0.67	0.82	0.81	0.86	0.64	0.80	0.83
AD / MCI	0.71	0.67	0.76	0.72	0.77	0.70	0.73	0.73
H-ADNI / MCI	0.77	0.75	0.76	0.76	0.81	0.71	0.77	0.80
H-ABIDE / ASD	0.60	0.57	0.57	0.60	0.65	0.64	0.63	0.66

Timing Analysis

Feature construction using FreeSurfer takes 2047 hours for each image 10. In contrast, CAE-staged and CAE-joint take 0.55s, and CAE-3D takes 0.45s on average to generate the latent embedding of each brain image

Conclusion

- CAE reconstruct brain images with very low error and performance comparable to FS features on classification tasks
- Less time