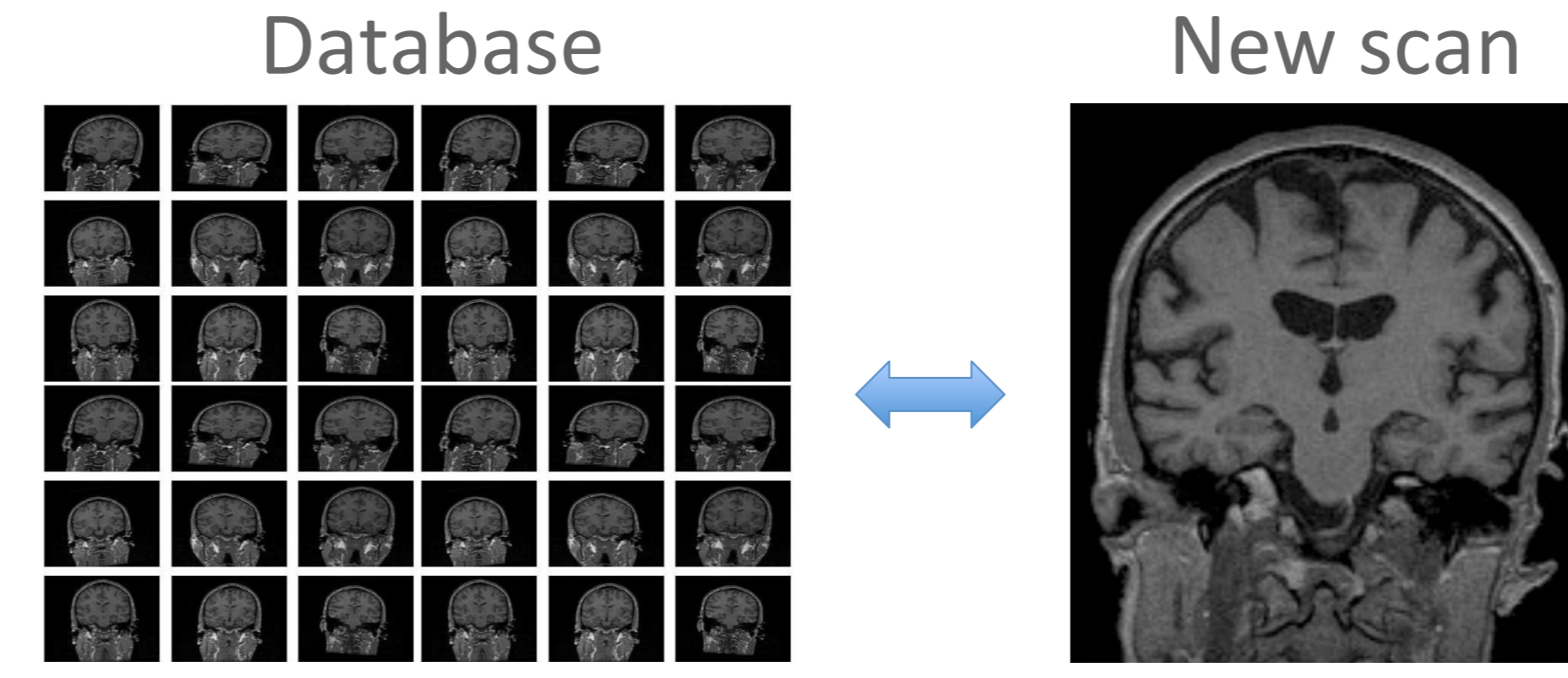
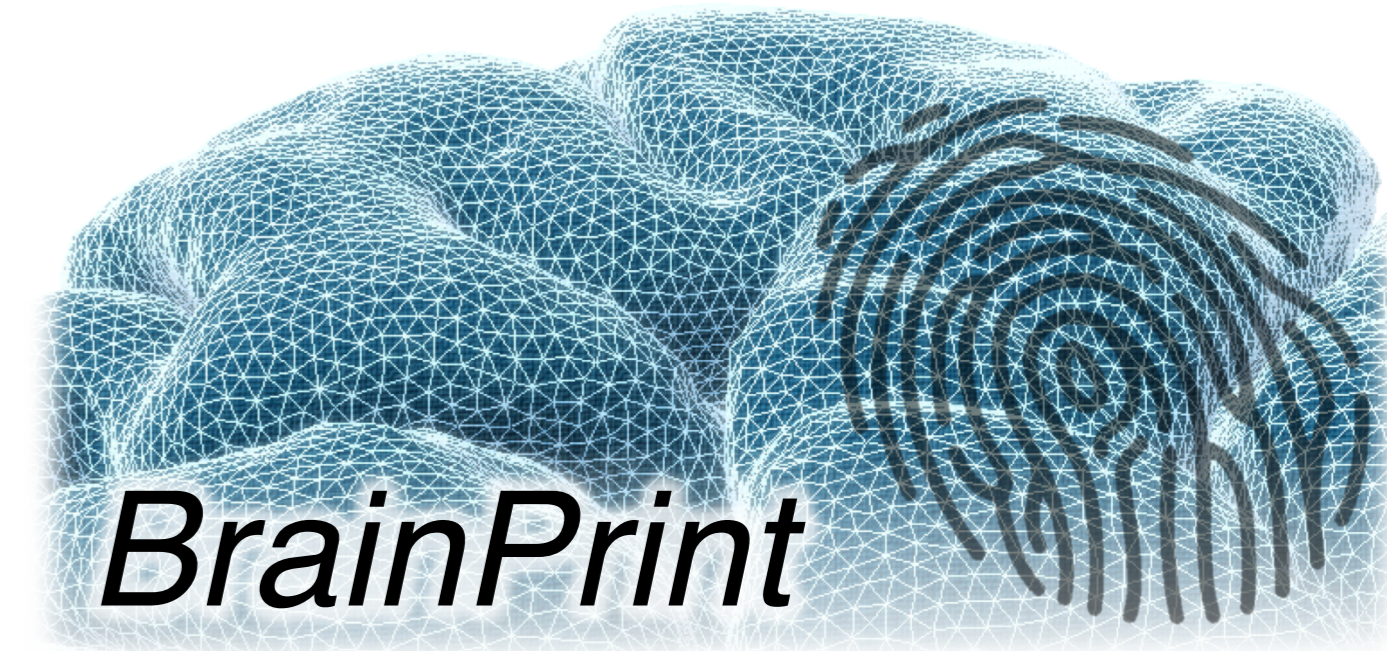


## Introduction

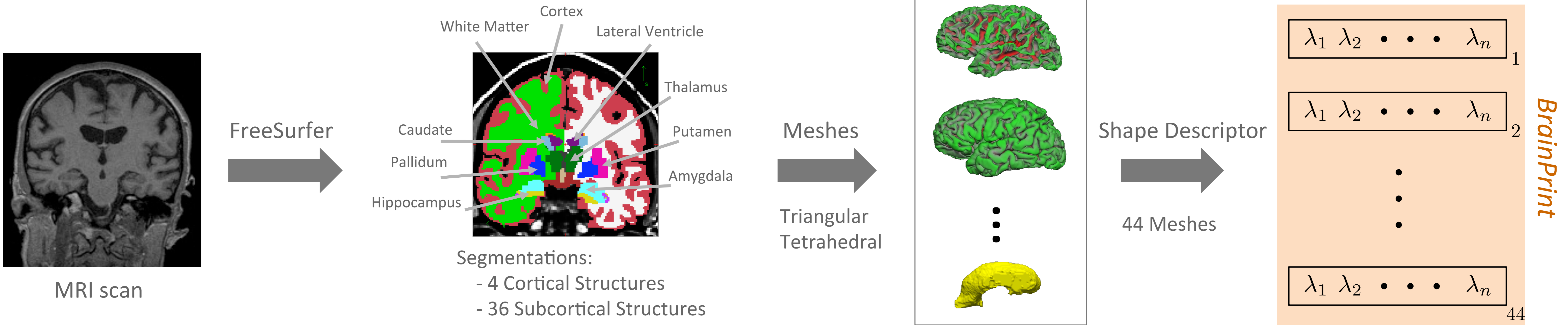
- Is it possible to identify an individual based on their brain?
- Challenges:
  - Morphological changes due to aging and disease
  - Scanning artifacts, inhomogeneities, imaging protocols
- BrainPrint*, a brain signature focusing on shape
  - Insensitive to imaging properties
  - Holistic, includes cortical and subcortical structures
- BrainPrint*, a useful framework for working with large datasets



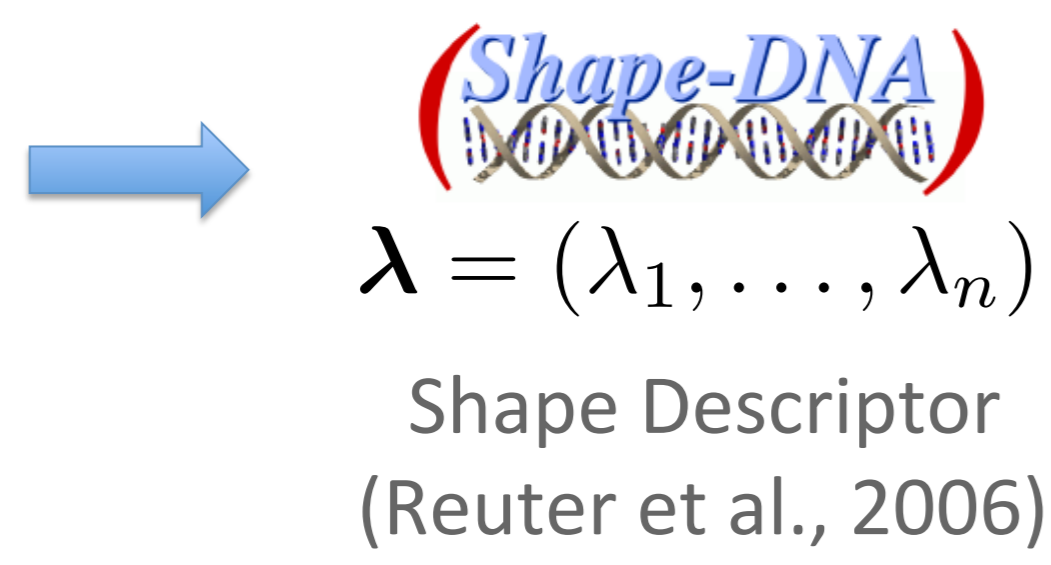
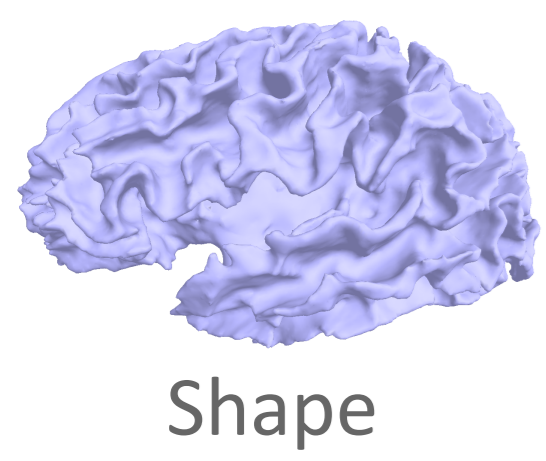
- Identify scans from same subject in database
- Decide if subject is not in database



## BrainPrint Overview



## Shape Descriptor



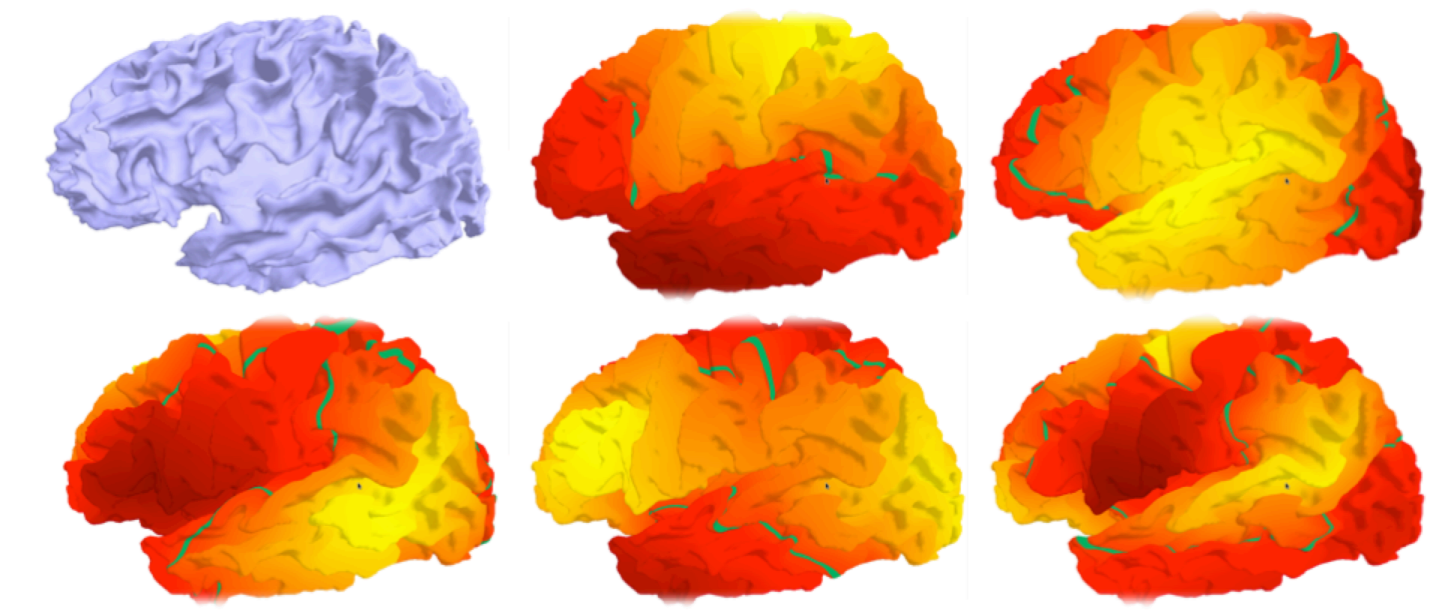
Helmholtz equation (Laplace-Beltrami Eigenvalue Problem):

$$\Delta f = -\lambda f$$

Solution: Eigenfunctions  $f_i$  with corresponding family of eigenvalues (Spectrum):

$$0 \leq \lambda_1 \leq \lambda_2 \leq \dots$$

Property: Isometric invariant to shape



Eigenfunctions show natural vibrations

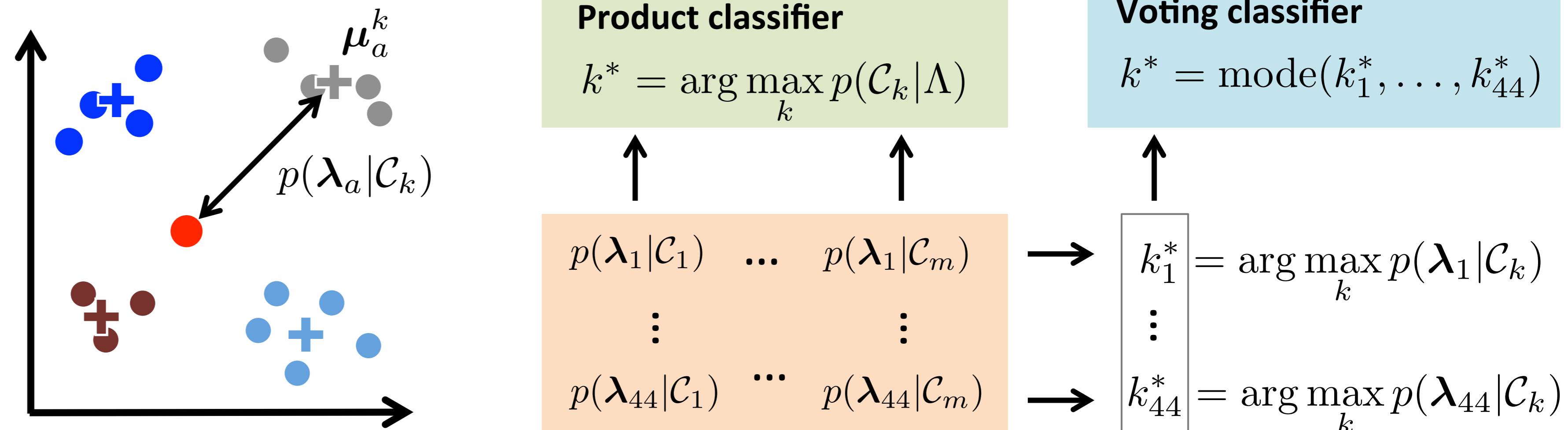
## Classifier

- Robust classifier that handles missing information
- Classification per structure as weak classifier
- Each subject in database as class, 3-6 points per class

Find subject class  $C_k$  for new scan with *BrainPrint*  $\Lambda = (\lambda_1, \dots, \lambda_{44})$

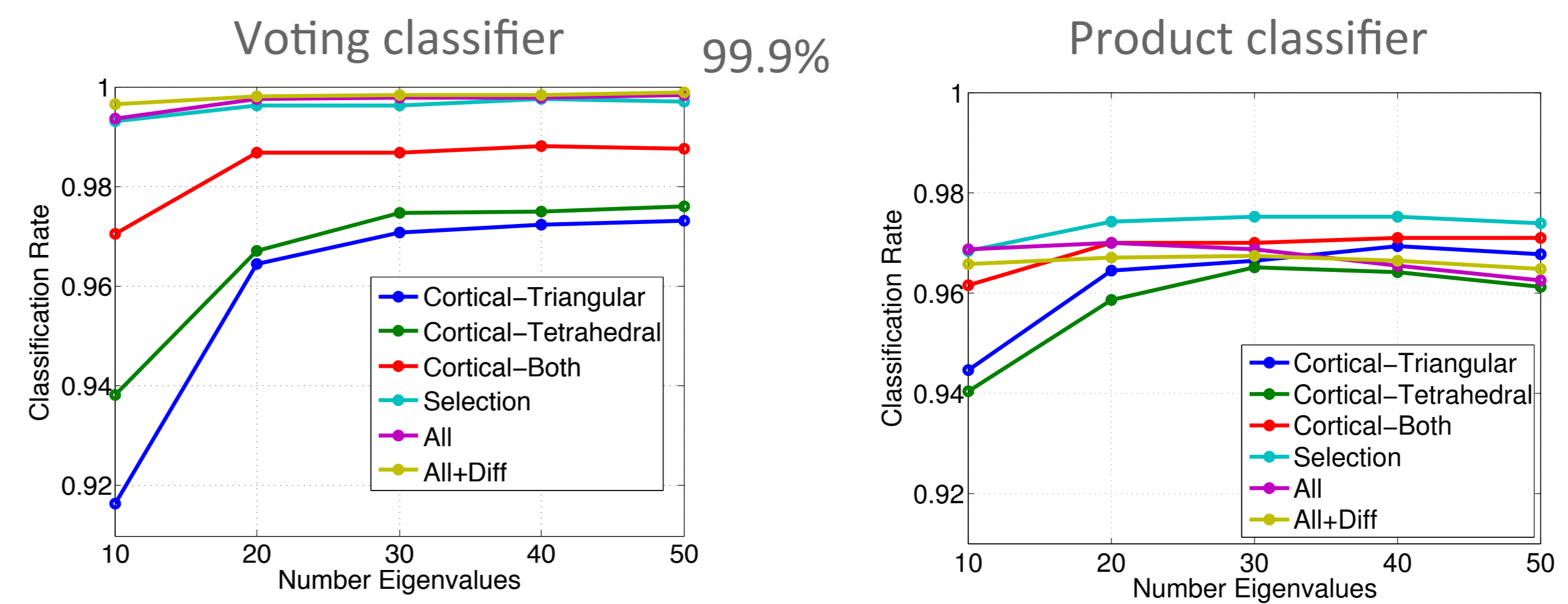
$$p(\lambda_a | C_k) \sim \mathcal{N}(\lambda_a; \mu_a^k, \Sigma_a) \quad a = 1, \dots, 44$$

$$p(C_k | \Lambda) \propto \prod_{a=1, \dots, 44} p(\lambda_a | C_k)$$



## Results

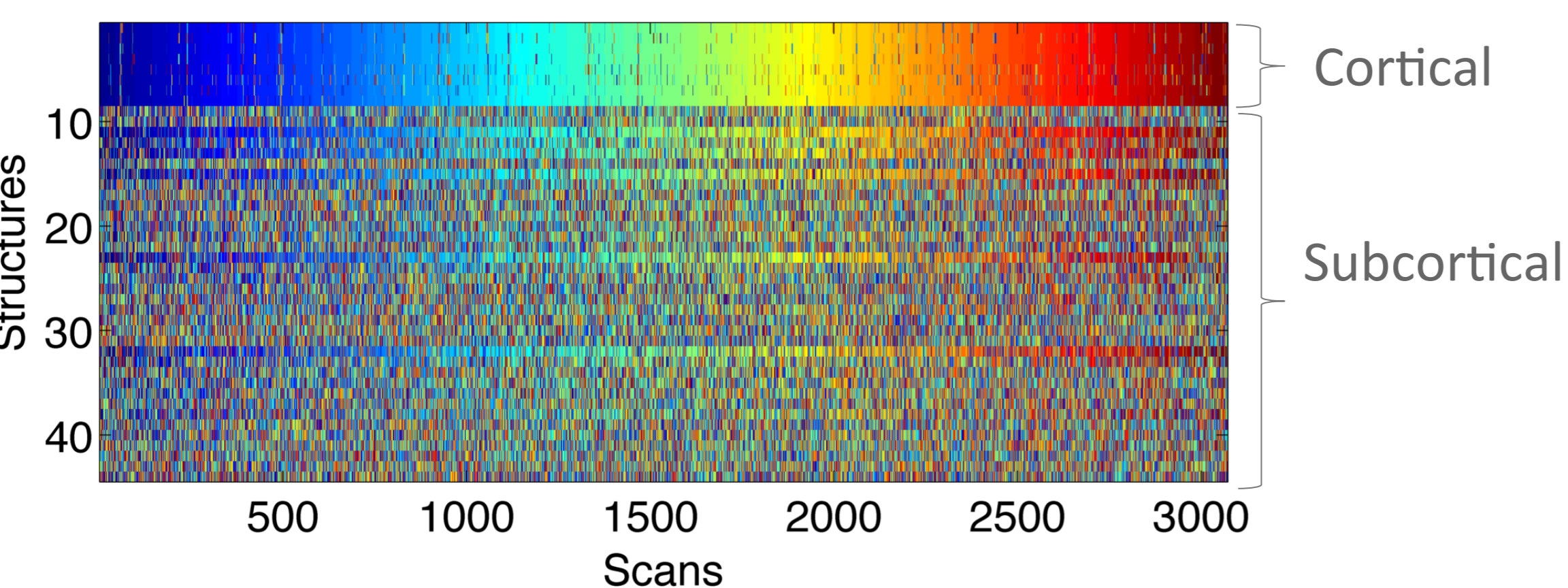
- Over 3000 scans from almost 700 subjects each with 3-6 longitudinal scans
- Data from the Alzheimer's Disease Neuroimaging Initiative (ADNI)
- Leave-one-scan-out experiments
- Variation of number of eigenvalues
- Variation of sets of structures:
  - Cortical Triangular (4), Cortical Tetrahedral (4), Cortical Both (8), Selection (15), All (44), All+Difference (48)



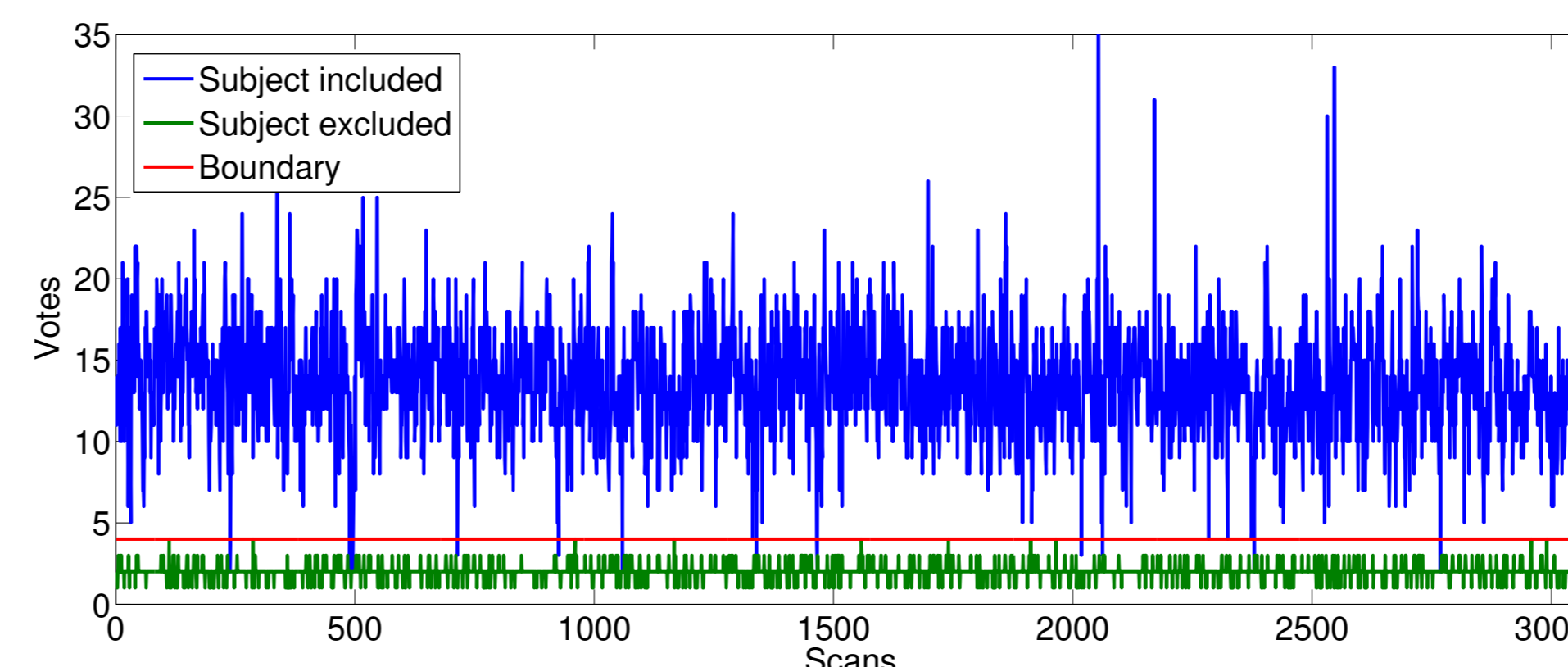
- Selection of best structures:
- Cortical structures (8)
  - Ventricles
  - Corpus Callosum
  - Cerebellum
  - Hippocampus
  - Left lateral ventricle
  - 3rd ventricle
  - Right lateral ventricle

## How well do individual structures perform?

Color: subject voted for by structure

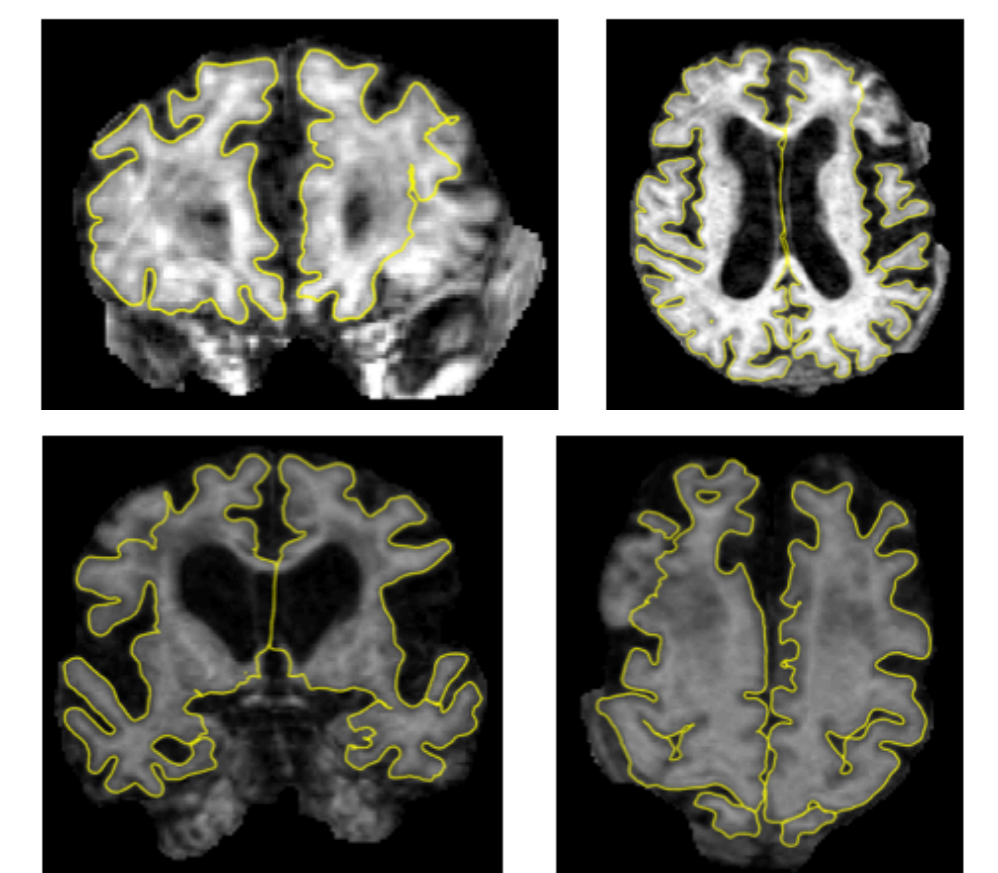


## Can we decide if a subject is not in the database?



0.49% false negative rate, 0% false positive rate

## Failed cases - segmentation errors



## Conclusions

- Extensive characterization of brain anatomy
- Compact characterization for handling large datasets
- Identification of subjects with very high accuracy
- Launchpad for more detailed follow-up analysis
- BrainPrint* does not interfere with anonymization of publicly available data because it does not connect to private information

## Future Work

- Concept of brain similarity
- BrainPrint* in CADDementia challenge for AD prediction
- Longitudinal scans over 36 months, similar results over longer periods?
- Quality control of FreeSurfer segmentations
- Detect anonymization errors in longitudinal studies

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