Neuroinformatics

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Introduction

- Neuroinformatics = Neuroscience + informatics

- Brede neuroinformatics toolbox and database


Brede neuroinformatics databases

Brede neuroinformatics database

Main component: Stereotactic coordinates.

Bibliographic information taken from PubMed,

Linked to other databases: PubMed, MeSH, fMRIDC, SenseLab.

“Poor man’s XML” (pXML): Database kept in a simplified version of XML, distributable on the internet.
Brede data model heavily inspired by BrainMap database (Fox and Lancaster, 1994): Paper (bibliographic information), experiment (summary image, paradigm, stimulus/response), location (stereotactic coordinates).

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<th>BrainMap</th>
<th>Brede</th>
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<td>251</td>
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<td>Locations</td>
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Data entry with a Matlab program for the information in “experiments” and “locations”.

Supplement to BrainMap
External components

External components, e.g., cognitive components “Cold pain”, “Alzheimer disease”, “BZ site GABA-A receptor”

External components represented in a directed acyclic graph

Corresponding to MeSH (NLM Medical Subject headings), linking to MeSH were equivalent item exists

Presently 274 components
Web-pages generated for each component

Corner Cube visualization (Rehm et al., 1998) with experiments that relates to the specific external component.

Clickable graphs generated with *dot* (Koutsosofios and North, 1996).
Modeling locations and volumes

Regard the “locations” as being generated from a distribution $p(x)$, where $x$ is in 3D Talairach space.

Kernel methods ($N$ kernels centered on each object: $\mu_n$) with homogeneous Gaussian kernel in 3D Talairach space $x$

$$\hat{p}(x) = \frac{(2\pi\sigma^2)^{-3/2}}{N} \sum_{n=1}^{N} e^{-\frac{1}{2\sigma^2}(x-\mu_n)^2}$$

$\sigma^2$ fixed or optimized with leave-one-out cross-validation.

Condition on, e.g., anatomical label, behavioral domain $c$: $p(x|c)$
Anatomical atlases

Conditioning on anatomical label \( p(x|c = \text{precuneus}) \).

Extract word and sub-phrases from the “Lobar anatomy” field in BrainMap, e.g., “Occipital gyrus” \( \rightarrow \) “occipital gyrus”, “occipital” “gyrus”.

Web-page for each label with Corner Cube visualization and probabilistic ANALYZE volumes in MNI-space.

Figure 2: “Precuneus” web-page with data from BrainMap from a part of the 3935 labeled locations.
Finding related volumes

Each experiment a volume: $p(x|\text{experiment} = \text{WOBIB 89})$ sampled on a fixed 8mm grid.

Location data can be compared to volume data.

Sorted list of similar volumes.

Figure shows result page with automatically generated corner cube visualization (Epstein and Kanwisher, 1998).
Image-based indices: Novelty

Novelty for an experiment, here: Minimum distance to other volume

Highest scoring in BrainMap:

- (Allison et al., 1994): Only EEG study in the database, only $x$ and $y$ coordinates are given.
- (Balslev et al., 2002): Perhaps a motion artifact.

Figure 3: The top of the novelty list for Brede experiments. The top novelty is an experiment by (Inoue et al., 2001) with a single activation in $(41, -68, 42)$. 
Image-based indices: SVD

Singular value decomposition of the (experiment × voxel) data matrix: \( \mathbf{ULV}^T = \text{svd}(\mathbf{X}) \). Columns of \( \mathbf{V} \) is called eigen-images.

Second eigenimage: One end interpreted as sensorimotor(“upper extremity movements”, “thumb-finger opposition”), other end as visual (“Watch virtual reality right hand grasping objects”).

Higher components have increasing spatial frequency.

Figure 4: Both ends of the second eigenimage \( \mathbf{v}_2 \) from an analysis of data from BrainMap.
Image-based indices: ICA

Independent component analysis of the \( X(\text{experiment} \times \text{voxel}) \) data matrix: \( AS = \text{ica}(X) \). \( A \) is the mixing matrix, \( S \) the sources.

ICA components: hand movement, visuospatial, words/verbs, audition, visual motion.

Figure shows both ends of the third to sixth source images \( s_3, \ldots, s_6 \). Data from Brede.
Image-based indices: Asymmetry

“Experiment” left/right asymmetry: Count the number of locations in the left side $X$

$$P_{\text{Bin}} = \sum_{0}^{X} \binom{N}{X} 0.5^N. \quad (1)$$

Normalize the value to $[-1; +1]$ range with $a = 1 - 2P_{\text{Bin}}$

When conditioning on anatomical labels:

- Right dominate ($+1$): ‘anterior cerebellum’,
Conclusion

Modeling 3D Talairach coordinates with kernel density estimators.

Visualization with Corner Cube Environments.

Novelty detection, finding related experiments, unsupervised modeling.


Results available on the Internet from hendrix.imm.dtu.dk more specifically http://hendrix.imm.dtu.dk/services/jerne/.
References


References
