Case Study 3: fMRI Prediction

fMRI Prediction Task,
Ridge, LASSO Review

Machine Learning for Big Data
CSE547/STAT548, University of Washington
Emily Fox
January 28th, 2014

©Emily Fox 2014

fMRI Prediction Task

- **Goal**: Predict word stimulus from fMRI image

Classifier (logistic regression, kNN, …) → HAMMER or HOUSE

©Emily Fox 2014
fMRI

~1 mm resolution
~1 image per sec.
20,000 voxels/image
safe, non-invasive

measures Blood Oxygen Level Dependent (BOLD) response

Typical fMRI response to impulse of neural activity
Typical Stimuli

Each stimulus repeated several times

fMRI Activation

fMRI activation for "bottle":

Mean activation averaged over 60 different stimuli:

"bottle" minus mean activation:
fMRI Prediction Task

- **Goal**: Predict word stimulus from fMRI image
- **Challenges**:
  - $p >> N$ (feature dimension >> sample size)
  - Cost of fMRI recordings is high
  - Only have a few training examples for each word

![Classifier](logistic regression, kNN, ...) → HAMMER or HOUSE

Zero-Shot Classification

- **Goal**: Classify words not in the training set
- **Challenges**:
  - Cost of fMRI recordings is high
  - Can’t get recordings for every word in the vocabulary

![Classifier](logistic regression, kNN, ...) → HAMMER or HOUSE
Zero-Shot Classification

- **Goal:** Classify words not in the training set
- **Challenges:**
  - Cost of fMRI recordings is high
  - Can't get recordings for every word in the vocabulary
  - We don't have many brain images, but we have a lot of info about the words and how they relate (co-occurrence, etc.)
  - How do we utilize this "cheap" information?

Classifier (logistic regression, kNN, …)

Semantic Features

<table>
<thead>
<tr>
<th>Semantic feature values: “celery”</th>
<th>Semantic feature values: “airplane”</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8368, eat</td>
<td>0.8673, ride</td>
</tr>
<tr>
<td>0.3461, taste</td>
<td>0.2891, see</td>
</tr>
<tr>
<td>0.3153, fill</td>
<td>0.2851, say</td>
</tr>
<tr>
<td>0.2430, see</td>
<td>0.1689, near</td>
</tr>
<tr>
<td>0.1145, clean</td>
<td>0.1228, open</td>
</tr>
<tr>
<td>0.0600, open</td>
<td>0.0883, hear</td>
</tr>
<tr>
<td>0.0586, smell</td>
<td>0.0771, run</td>
</tr>
<tr>
<td>0.0286, touch</td>
<td>0.0749, lift</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>0.0000, drive</td>
<td>0.0049, smell</td>
</tr>
<tr>
<td>0.0000, wear</td>
<td>0.0010, wear</td>
</tr>
<tr>
<td>0.0000, lift</td>
<td>0.0000, taste</td>
</tr>
<tr>
<td>0.0000, break</td>
<td>0.0000, rub</td>
</tr>
<tr>
<td>0.0000, ride</td>
<td>0.0000, manipulate</td>
</tr>
</tbody>
</table>
Zero-Shot Classification

- From training data, learn two mappings:
  - S: input image \( \rightarrow \) semantic features
  - L: semantic features \( \rightarrow \) word

- Can use “cheap” co-occurrence data to help learn L

Features of word \( \rightarrow \) Classifier (logistic regression, kNN, ...) \( \rightarrow \) HAMMER or HOUSE