Convolutional neural network-based encoding and decoding of visual object recognition in space and time
An Introduction

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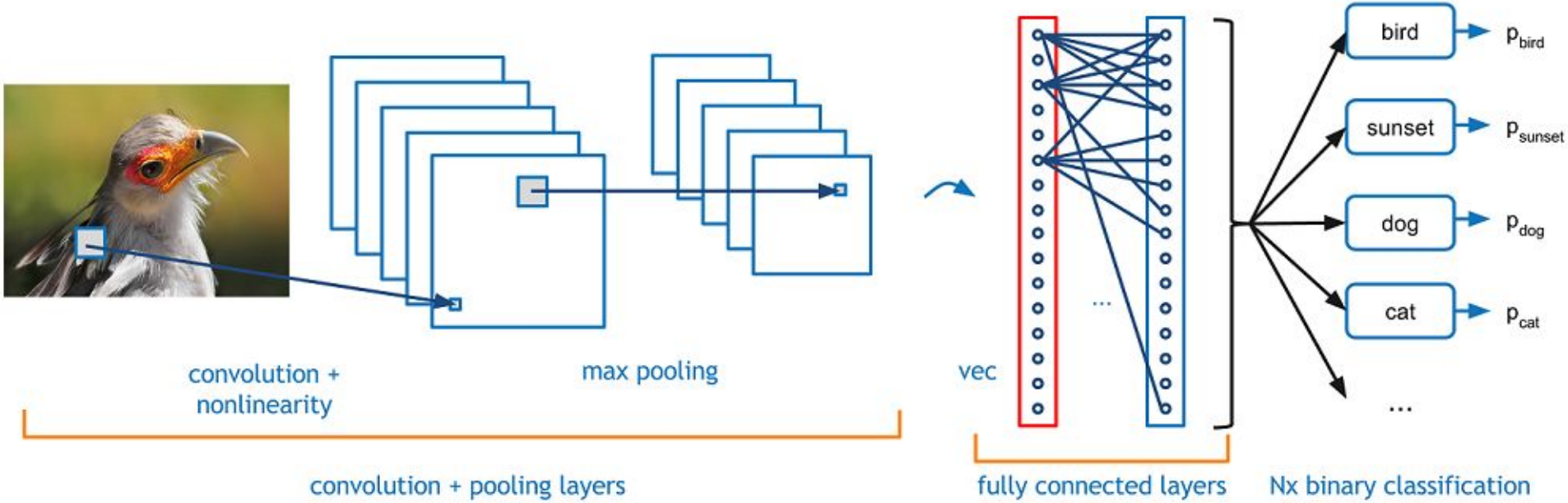
Agenda

1. CNN and Feature Extraction
2. Task: Object Recognition
3. Experiment Overview

Convolutional Neural Network



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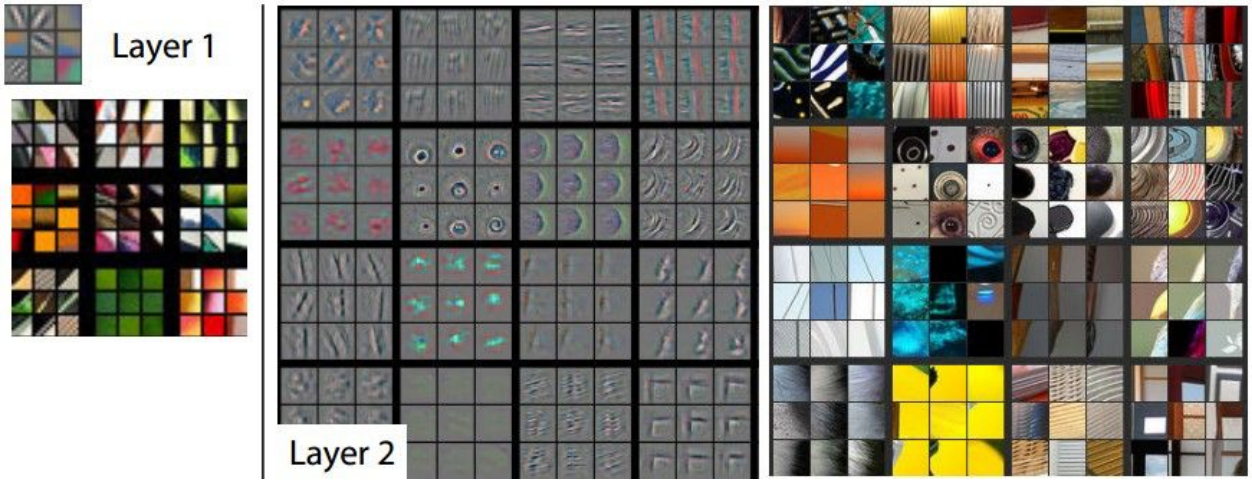
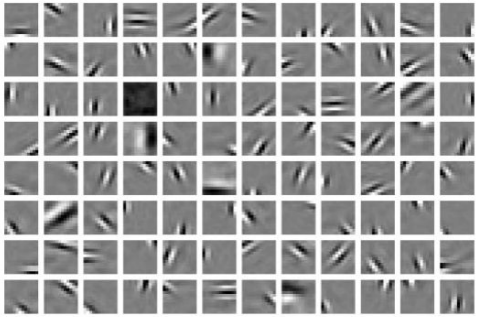
Feature Extraction





- similar to what is known about the response properties or neuronal populations in V1

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Task: Object Recognition

- CNN allow us to learn the features and not hand-designed
- Invariant to scale, translation and deformation

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Experiment Overview

- Combine CNNs with electrophysiological measurements of neuronal activity such as electroencephalography (EEG) or magnetoencephalography (MEG) to probe the dynamics of object processing in the human brain.
- Encoding model framework to probe how CNN-based representations are expressed in space and time across the cortical surface using MEG.

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Experiment Overview

- Each of the 15 participants are presented 1,000 images of well-identifiable natural objects
- Magnetoencephalogram are recorded
- A random subset of 50 images was repeated 10 times (validation set)
- Majority of 950 images was presented once (estimation set).
- There was no specific task, and the participants were asked to passively view the images.

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Experiment Overview

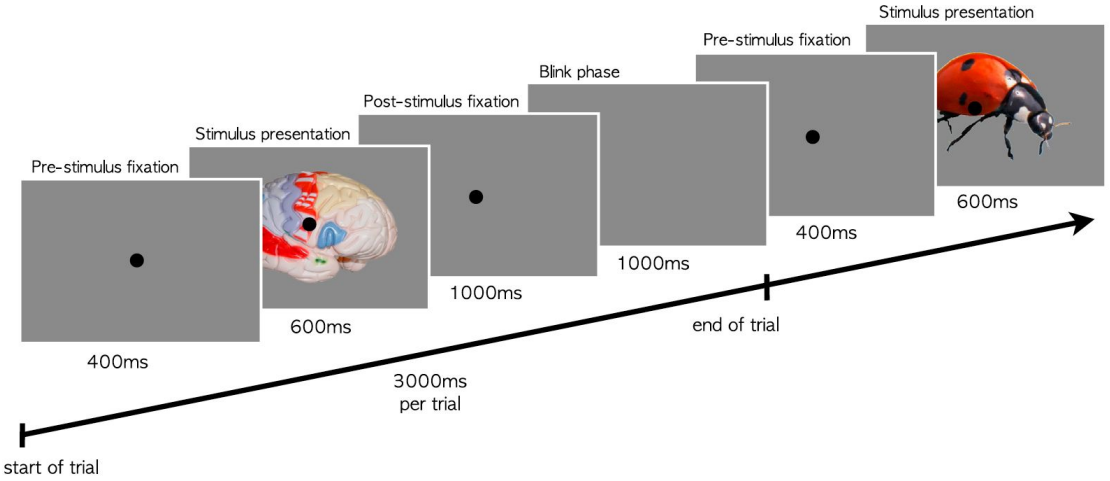

Fig. 1. Design of individual trials. Images of objects were presented for 600 ms, preceded and followed by fixation periods. Participants could blink between each fixation. The experiment consisted of 1,450 trials of 3 s length, resulting in 72 min of MEG acquisition time per participant.

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Experiment Overview

- The computational goal of arriving at invariant cortical representations of objects is believed to be realized by transforming the retinal input through a series of nonlinear processing steps in the ventral stream.
- The resulting representations are assumed to be reflected in characteristic patterns of brain activity and to be discoverable by using candidate representations to predict brain activity within an encoding model framework.

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Experiment Overview

- To link neural networks to patterns of brain activity, they modelled cortical source activity from the MEG sensor activity using source reconstruction on individual brain surface models
- For each participant they developed a source-wise encoding model, predicting the modelled source activity globally using CNN representations.
- The encoding model uncovers when and where cortical activity is similar to these representations.
- The resulting encoding model can also be used for decoding, where the most likely stimulus is selected from a set of candidate stimuli based on observed brain activity.

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