Time, Space and Computation: Converging Human Neuroscience & Computer Science

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COMPUTATION

Predictions:
- **type**: outdoor
- **semantic categories**:
  - picnic_area: 0.14, patio: 0.12,
  - yard: 0.11, veranda: 0.11,
  - boardwalk: 0.06
- **scene attributes**:
  - natural light,
  - man-made, nohorizon, soothing,
  - foliage, trees, vegetation, warm,
  - open area, leaves

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Jitendra Malik
Pietro Perona
Andrew Zisserman
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Antonio Torralba
SPACE

Moshe Bar
Russell Epstein
Nancy Kanwisher
Kalanit Grill-Spector
James Haxby
Talia Konkle

Big-TOS
LOC
Small-LO
LOS
Big-PHC
Small-OTS
OPA
RSC
PPA
Computation with millions of instances
Deep architectures
Geoffrey Hinton, Yann LeCun

**Object-centric network**

**Scene-centric network**
Object-centric deep architectures

**R-CNN**: Regions with CNN features

Girshick, Donahue, Darrell & Malik (CVPR 2014)

**VGGNet**: Very deep ConvNet

Simonyan & Zisserman (2014)

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**Improvements in Object Detection**

(graph by D. Hoeim)

**Top-5 ImageNet Classification Error (%)**

Very deep ConvNet

(deep ConvNet (Clarifai, 2013)

13 layers  16 layers  19 layers

12.5  8.2  7.6  7.5

better
Places Model
places.csail.mit.edu

NIPS 2014 release: 2.5 million images, 205 scene categories

Zhou, Lapedriza, Xiao, Torralba & Oliva (2014), NIPS
Deep architectures
A Visualization of the learned representation for each unit

Object-centric CNN
C1 filters  C2 feature maps  C5 feature maps  C7 feature maps

Scene-centric CNN
C1 filters  C2 feature maps  C5 feature maps  C7 feature maps

Object like shapes  Space like shapes

Zhou, Lapedriza, Xiao, Torralba & Oliva (2014), NIPS
Layer 5: Artificial Receptive fields

Object-centric units

Scene-centric units

Zhou, Lapedriza, Xiao, Torralba & Oliva (2014), NIPS
Non invasive neuro-imaging techniques

**MEG**
(msec-resolution)
Magneto encephalography

**fMRI**
(mm-resolution)
Functional Magnetic Resonance Imaging

Sensors (time) Voxels (space)
Shepard et al., 1980; Kruskal and Wish., 1978; Edelman et al. 1998; Kriegeskorte et al., 2008; Mur et al., 2009; Liu et al., 2013
Representational Geometry

Nikolaus Kriegeskorte (2008)

“RDMs as a hub to relate different representations across sensors and models”
Time-specific fMRI searchlight analysis

A spatially unbiased view of the relations in similarity structure between MEG and fMRI

Cichy, Pantazis, Oliva (in preparation)
The dynamics of object recognition
Object recognition in context
Spatiotemporal maps of correlations between MEG and fMRI

100 msec

Visual areas

Inferior-temporal cortex

100 msec

Visual areas

Parahippocampal cortex
Algorithmic-specific fMRI searchlight analysis

A spatially unbiased view of the relations in similarity structure between deep architectures and fMRI

Cichy, Khosla, Pantazis, Torralba, Oliva (in preparation) See also Kaligh-Razavi & Krigeskorte (2014)
Spatiotemporal map of correlations between fMRI and model layers
Can we predict which images are memorable?
Predicting Visual Memorability

~ 60,000 photographs with Memorability scores

Aditya Khosla
Predicting Visual Memorability

~ 60,000 photographs with Memorability scores

Most memorable

Less memorable

Human $\rho = 0.68$

Deep feature $\rho = 0.64$
Cognitive-level Algorithms
Memorability: metric of the utility of information

Understand human memory
Data Visualization

Diagnose memory problems
Mobile applications

Design mnemonic aids
"heavy"
"lourds"

Retrieve better images from search

Logos
Slogans - words-

Social Networking

Computer Graphics - cognitive saliency

Education - Individual difference

Face Memorability

Summarize Big data - images, videos
Time, Space and Computation
A converging framework for hypothesis testing

Power of Prediction
Comparing large-scale processing between natural and artificial systems will not only allow us to understand why biological systems have implemented a certain mechanism, but will allow

- Studying the strategies that work best for performing specific tasks
- Characterizing the operations when the system is broken
- Exploring the alternatives biological systems have not taken

A.I “Alien” Intelligence (Kevin Kelly, Wired magazine)