# How transferable are features in deep neural networks?

9 December 2014 Jason Yosinski



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## AlexNet



Krizhevsky, Sutskever, Hinton – NIPS 2012

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Krizhevsky, Sutskever, Hinton – NIPS 2012

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### (a) DPM detections

(b) Parts

# Image





## (c) DPD

# labels



# **Deep Fragment** Embeddings







# Layer 1 Gabor + color blobs























# Layer number

# specific







# Layer number

# specific









# general



# specific















# ImageNet



### 1000 Classes

Deng et al., 2009

# ImageNet



### 1000 Classes



### 500 Classes



B

### 500 Classes

Deng et al., 2009

















Train using Caffe framework (Jia et al.)

















Train using Caffe framework (Jia et al.)















500 Classes



# Train using Caffe framework (Jia et al.)





# A Images





# B Images












































































## ImageNet has many related categories...

# **Dataset A: random** gecko fire truck baseball panther rabbit gorilla



#### **Dataset B: random**

# garbage truck toucan radiator binoculars lion bookshop

# ImageNet has many related categories...

### Dataset A: man-made

garbage truck fire truck radiator baseball binoculars bookshop

#### **Dataset B: natural**

gorilla gecko toucan rabbit panther lion











#### • Measure general to specific transition layer by layer



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• Transferability governed by:



- Measure general to specific transition layer by layer
- Transferability governed by:
  - lost co-adaptations
### Conclusions



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  - difference between base and target dataset

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- Measure general to specific transition layer by layer
- Transferability governed by:
  - lost co-adaptations
  - specificity
  - difference between base and target dataset
- Fine-tuning helps even on large target dataset

#### Tonight: Demo Tomorrow: Poster Wed37

### Tonight: Demo **Tomorrow: Poster Wed37**



#### Jeff Clune





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de Montréal







## Tonight: Demo Tomorrow: Poster Wed37



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Yoshua Bengio



Université nh de Montréal

Funding:

- NSF CDI Grant ECCS 0941561
- DARPA Matter Compiler Grant
- NSERC
- Ubisoft
- CIFAR
- NASA Space Technology Research Fellowship



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# Thanks! **Tonight: Demo Tomorrow: Poster Wed37**



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