An Overview of Deep Learning Research at LLNL

LLNL/UC Davis Data Science Collaboration

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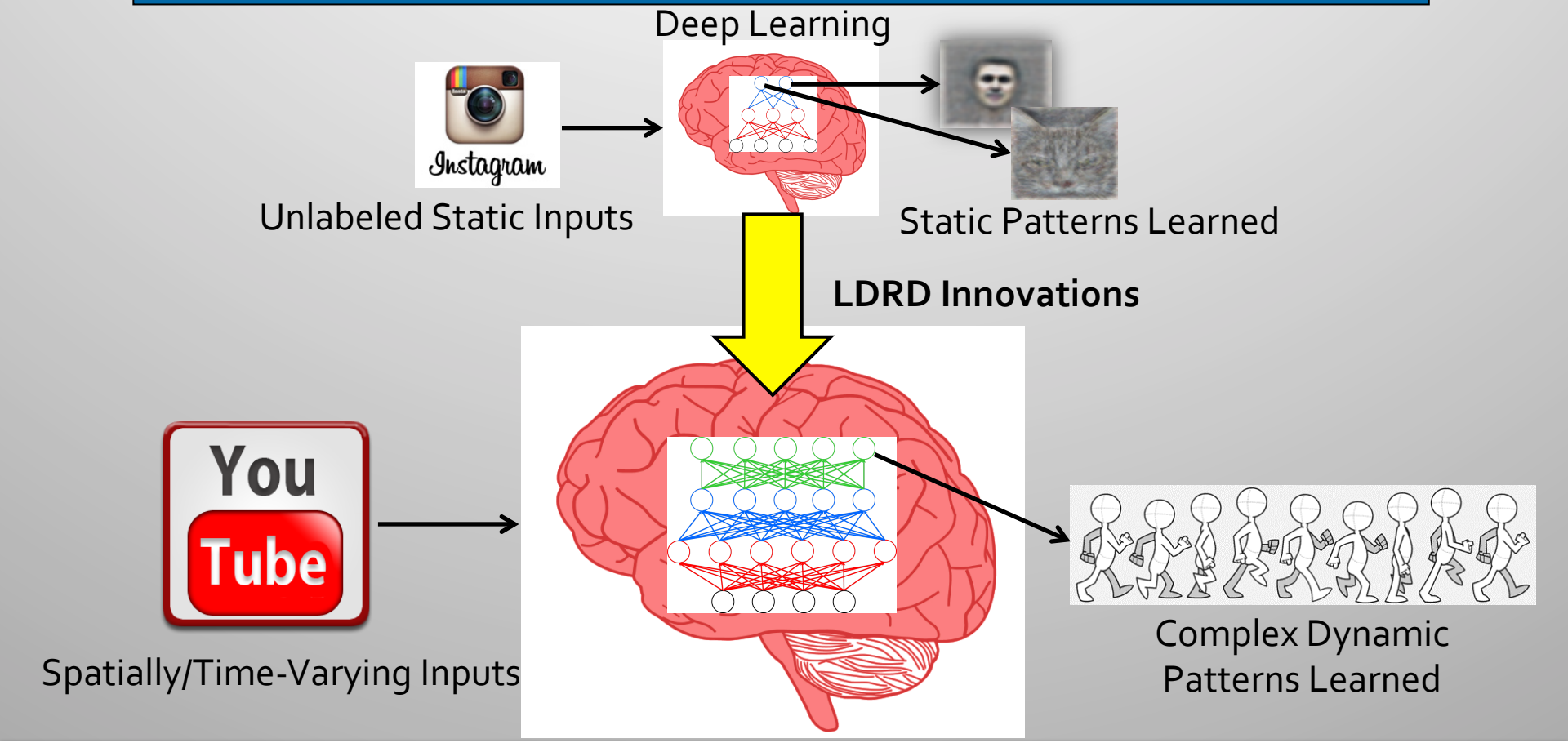
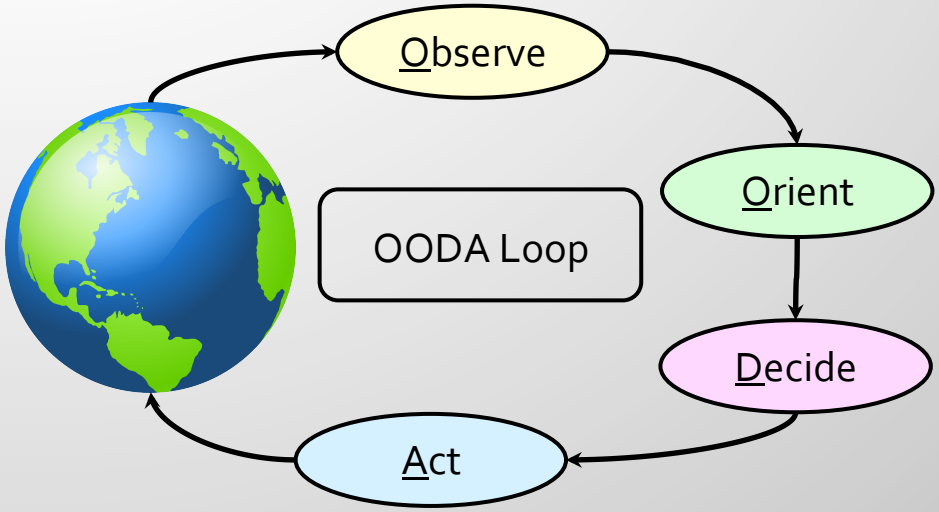
The overall goal of this project is to scale up Deep Learning algorithms using HPC and develop new Deep Learning approaches for finding inherent complex time-varying patterns



LLNL Missions Depend on Finding Patterns in Data

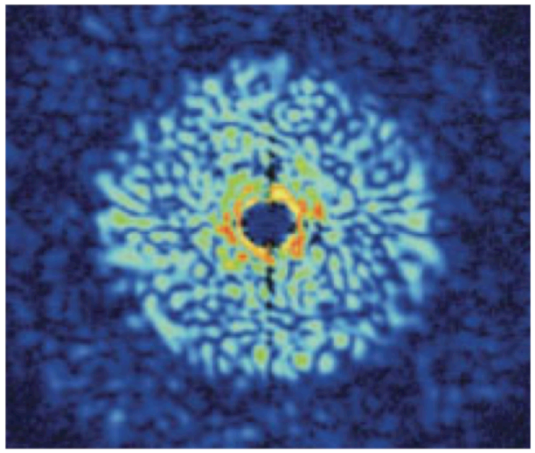
- Counter-Terrorism
- Non-Proliferation
- National Science
  - National Ignition Facility
  - Linac Coherent Light Source



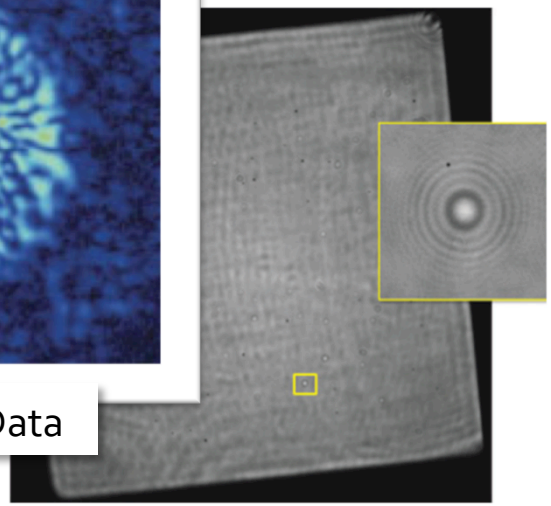
New sensors collect an ever increasing amount of data

- "Big Data", but "Small Labels"

Deep Learning Neural Networks can automatically learn basis patterns from massive amounts of *unlabeled* data

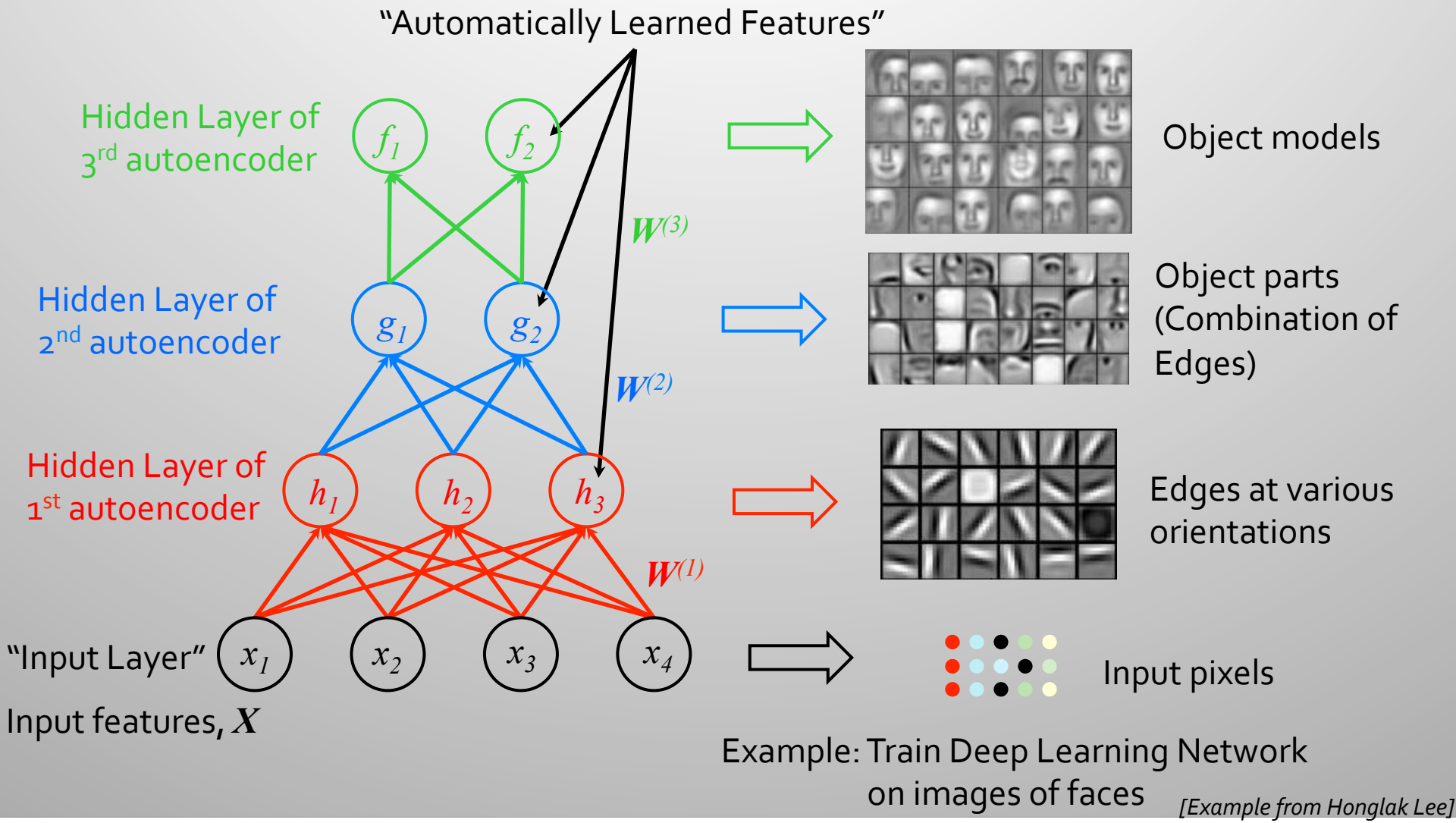


Analysis of LCLS Data



Optics Inspection for the NIF

Deep Learning Offers a Viable Approach for Unsupervised Feature Learning



Example: Train Deep Learning Network on images of faces

[Example from Honglak Lee]

We Focus on Two Areas in Deep Learning Research

1. Scaling DL algorithms using HPC
   - Enable rapid training of massive networks
     - Complex behavioral patterns need complex models
       - E.g., Dynamic spatio-temporal patterns
     - Better exploits massive amounts of data
       - Complex models + lots of data → reduce bias and variance
   - Scaling to speed up training
     - Faster training enables faster optimization of network topology
2. Developing and applying unsupervised DL algorithms
   - Training of "grandmother cells" in very large datasets
   - Improving the modeling of spatio-temporal patterns
     - Many data types naturally contain spatio-temporal patterns
       - E.g., video and sound

Learning "Grandmother Cells" from Unlabeled Imagery

- Le, Ng, et al. 2011 showed that the "Google Brain" automatically learned class-specific neurons (i.e., grandmother neurons)

Maximally Stimulating Input Images

- We have extended these studies on our GPU cluster
  - Training on TrecVid2011 data
  - Training on Yahoo Flickr Creative Commons 100 Million (YFCC100M) data (10x larger corpus than Le's)

YFCC100M Offers Opportunity to Learn Semantic Space for Images, Videos, and Text

- One of the Largest Publicly Available Multimedia Datasets
  - 99.3 million images, 0.7 million videos
  - Corresponding metadata includes: description, camera type, and tags
- LLNL's Video Analytics LDRD is working with ICSI to provide speech and video features for the geo-location task in MediaEval2014

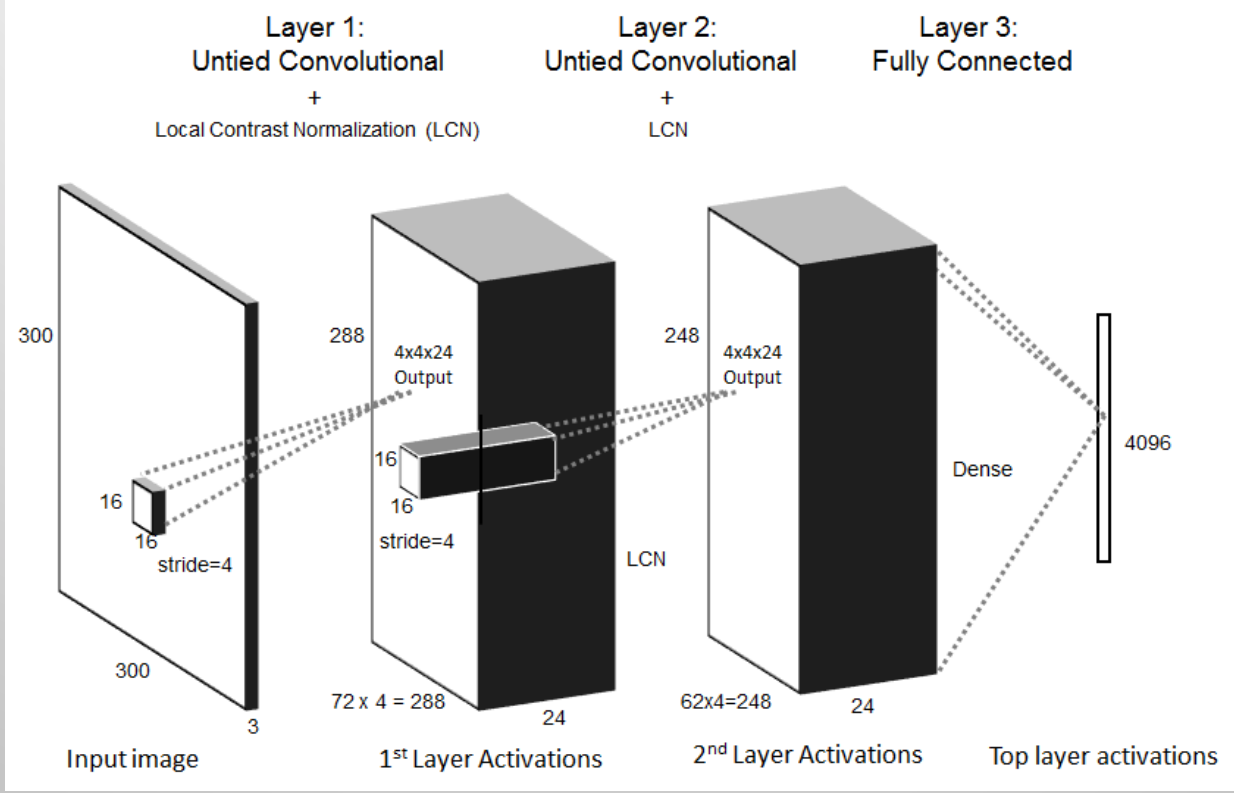
ICSI Works With Yahoo Labs and Lawrence Livermore Lab to Offer Analytics Tools for Over 100 Million Flickr Images and Videos

50TB Computing Program Runs Analysis on the Entire Flickr Creative Commons Dataset, One of the Largest Public Multimedia Datasets Ever Released to the Public

MARKET WIRED ICSI July 3, 2014 9:00 AM

BERKELEY, CA--(Marketwired - Jul 3, 2014) - The International Computer Science Institute (ICSI), a leading center for computer science research, today announced a collaboration with Yahoo Labs and Lawrence Livermore National Laboratory to process and analyze the recently released Yahoo Flickr Creative Commons 100 Million (YFCC100M) dataset, a publicly available corpus of user-generated content comprising more than 100 million images and videos.

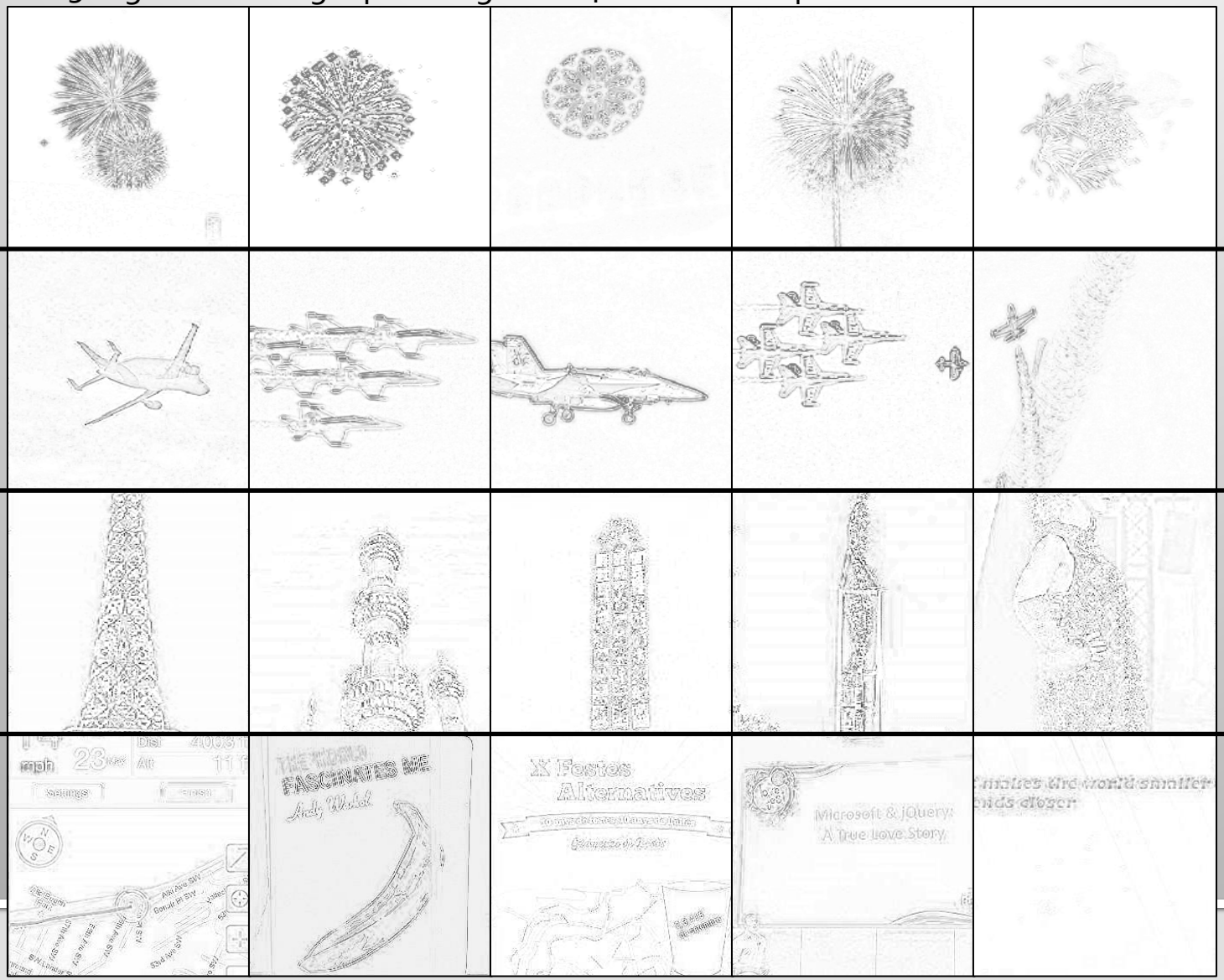
Learning Image Features from YFCC100M: Our Stacked RICA Autoencoder



- 16 Billion trainable parameters
- Each layer trained in <3days on 100 GPU cluster

Top Activated Images for Several 3rd Layer Neurons Reveal Interesting Learned Concepts

5 Highest scoring input images for 4 different output neurons



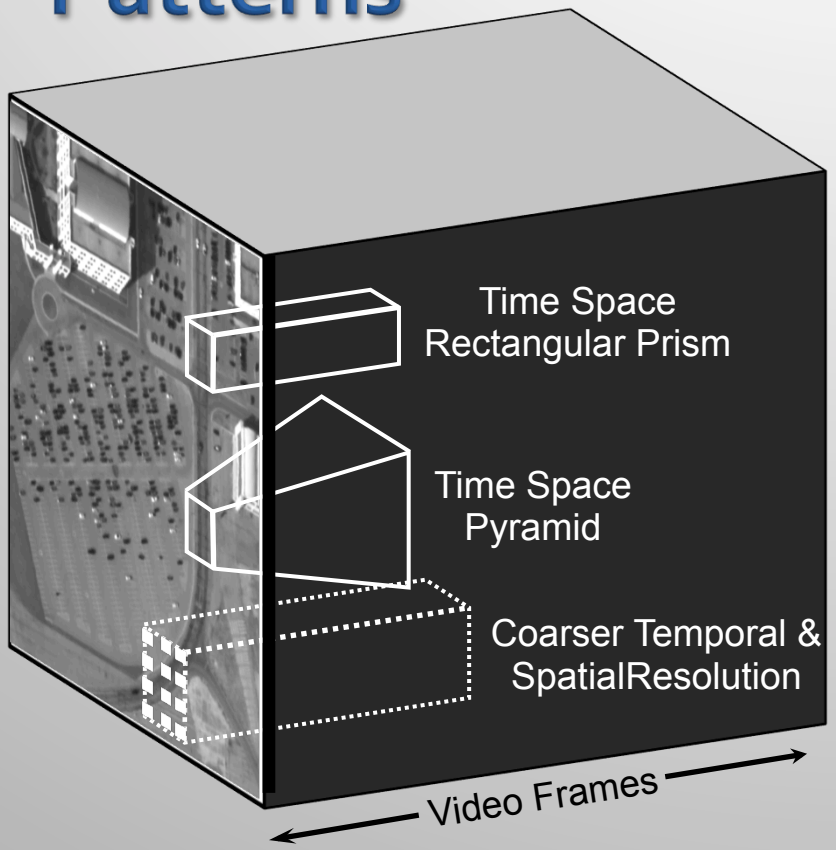
"Fireworks Neuron"

"Airplane Neuron"

"Lattice Tower Neuron"

"Pictures w/Text Neuron"

We are Beginning to Investigate New Approaches for Learning Spatio-Temporal Patterns



- Optimizing time-space receptive field shapes
- Multi-resolution receptive fields in time and space
- Predictive autoencoders
  - Each layer learns to autoencode future inputs

LLNL is Investigating Deep Learning for Overhead Imagery/Video

- What do grandmother neurons learn from overhead imagery and video?
  - Roads? Land use categories? Vehicles? Pedestrians?
- What is the most appropriate network topology for this data?
- Dataset goals:
  - Improved tracking of movers
  - Background/foreground identification
  - Mover anomaly detection