ALEXNET

THE IMAGENET LARGE SCALE VISUAL RECOGNITION CHALLENGE (ILSVRC)

Backpack

Flute

Strawberry

Traffic light

Backpack

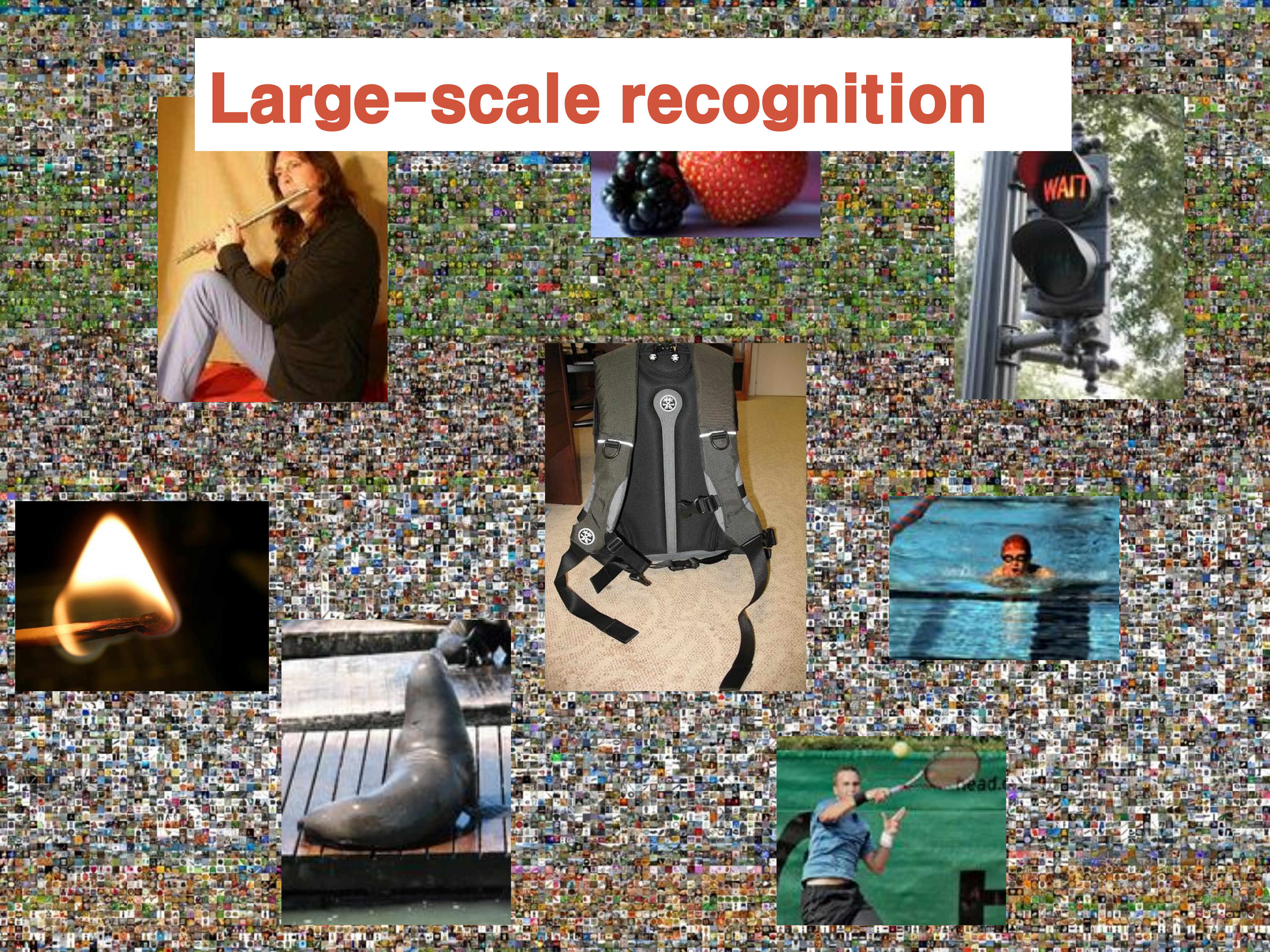
Matchstick

Bathing cap

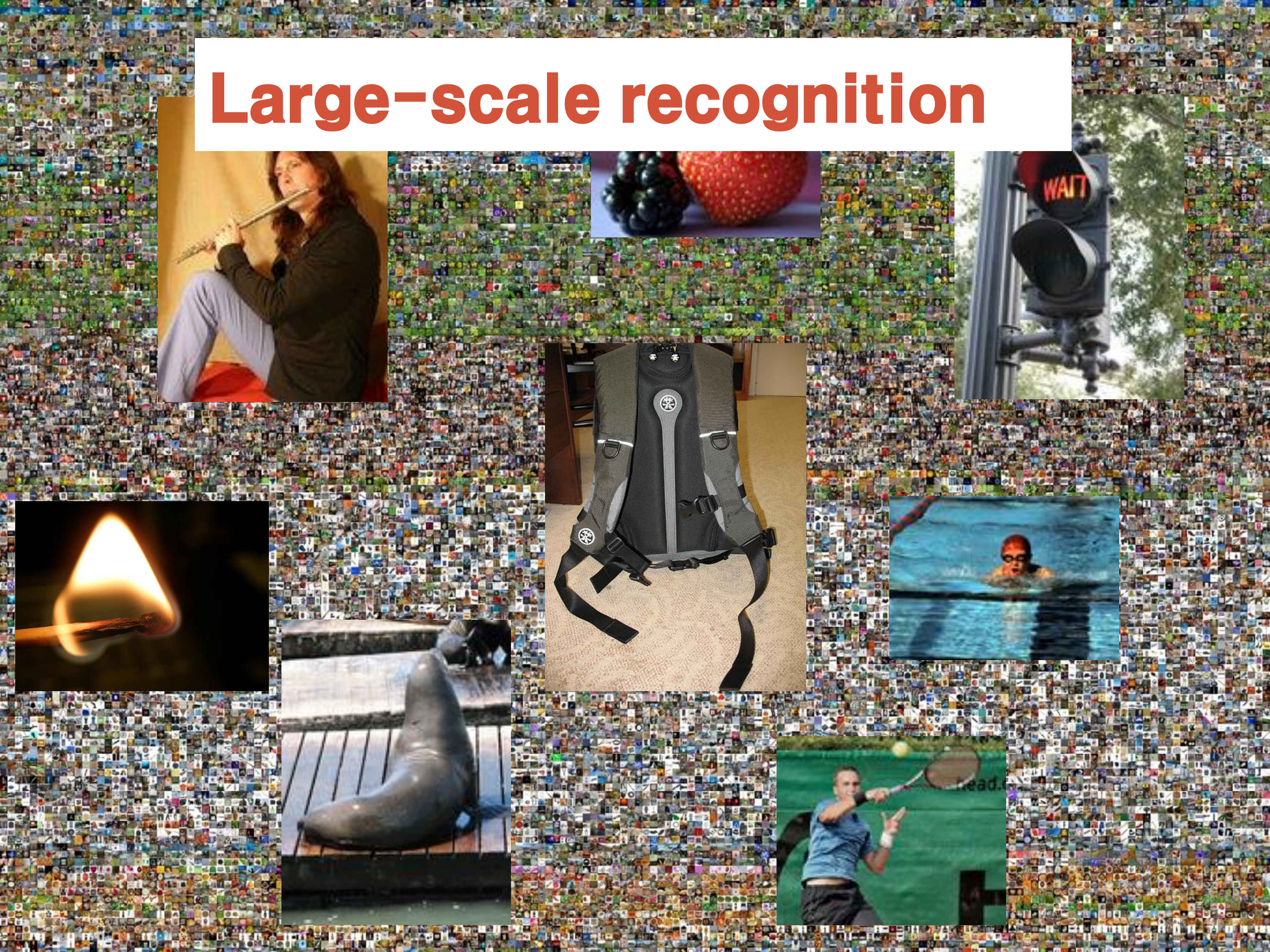
Sea lion

Racket

Large-scale recognition

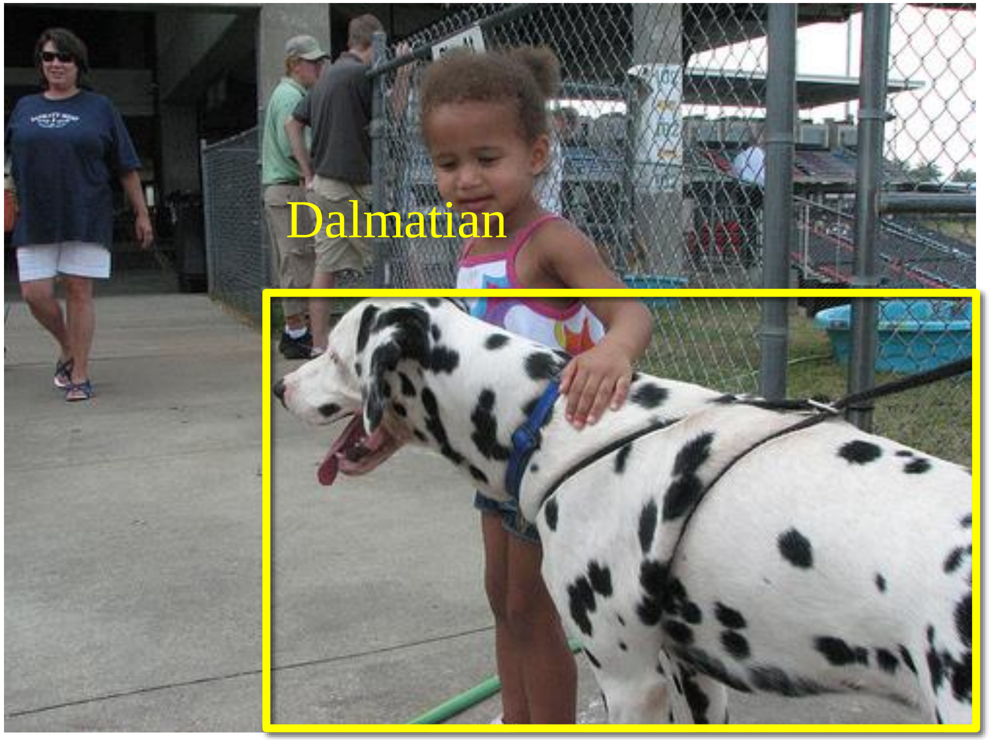


Large-scale recognition



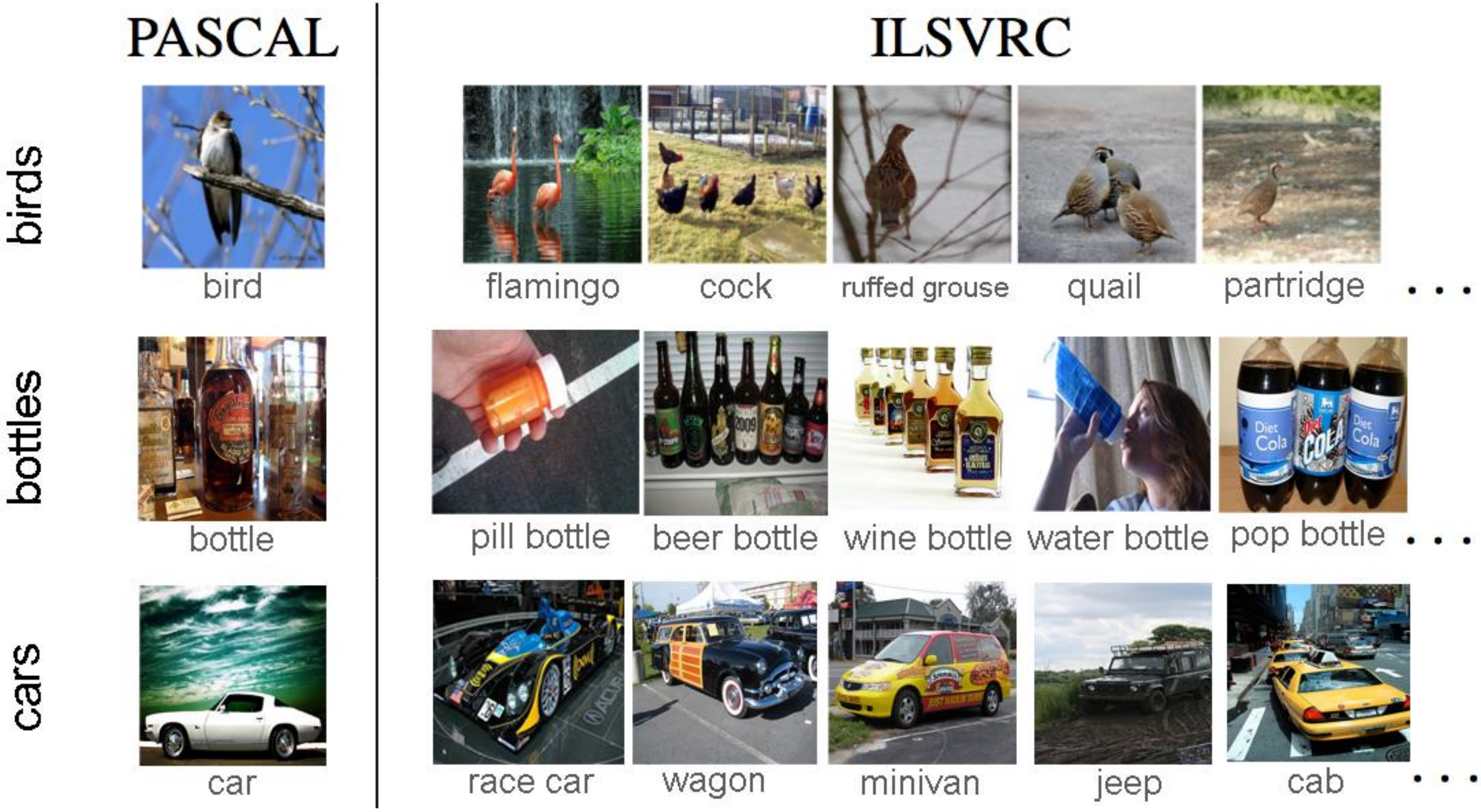
Large Scale Visual Recognition Challenge (ILSVRC) 2010-2012

1000 object classes **1,431,167 images**



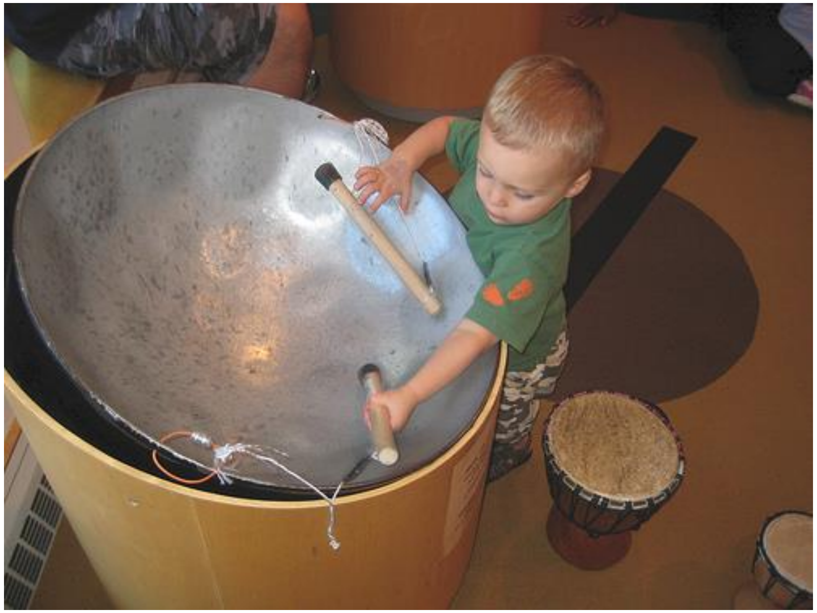
http://image-net.org/challenges/LSVRC/{2010,2011,2012}

Variety of object classes in ILSVR C



ILSVRC Task 1: Classification

Steel drum



ILSVRC Task 1: Classification

Steel drum

Output:
Scale
T-shirt
Steel drum
Drumstick
Mud turtle

✓

Output:
Scale
T-shirt
Giant panda
Drumstick
Mud turtle

✗

ILSVRC Task 1: Classification

Steel drum

Output:
Scale
T-shirt
Steel drum
Drumstick
Mud turtle

✓

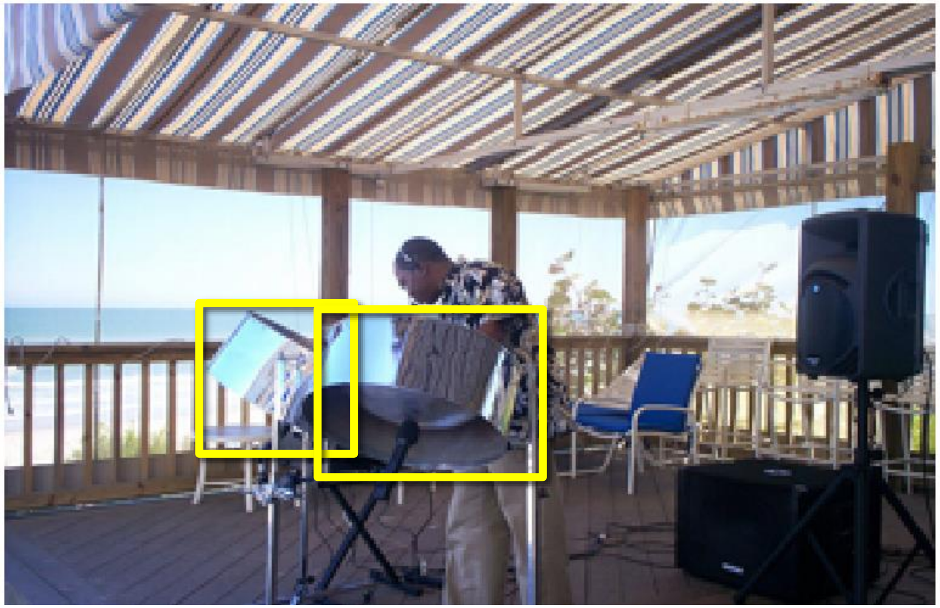
Output:
Scale
T-shirt
Giant panda
Drumstick
Mud turtle

✗

$$\text{Accuracy} = \frac{1}{N} \sum_{\substack{N \\ \text{images}}} 1[\text{correct on image i}]$$

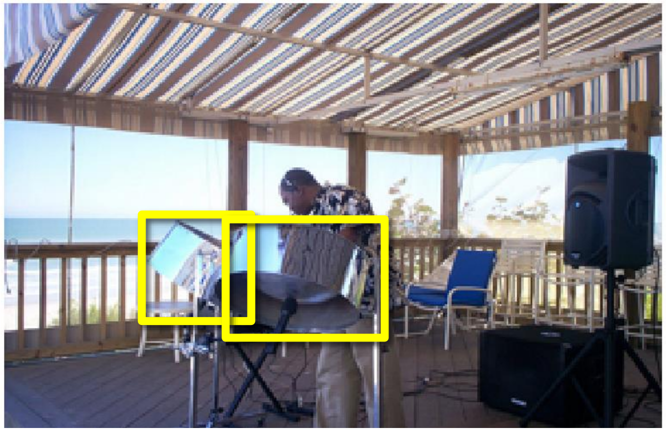
ILSVRC Task 2: Classification + Loca lization

Steel drum



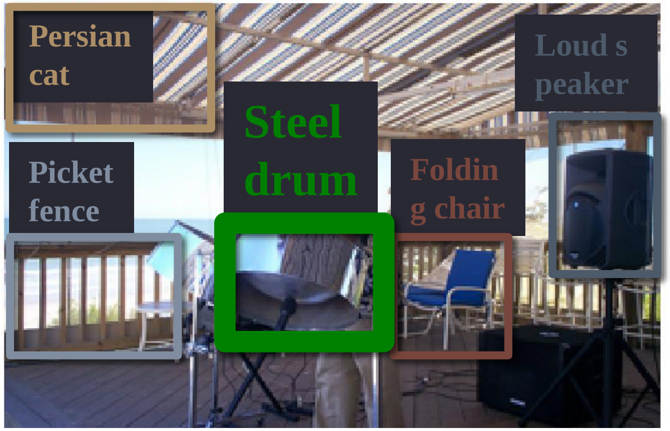
ILSVRC Task 2: Classification + Localization

Steel drum



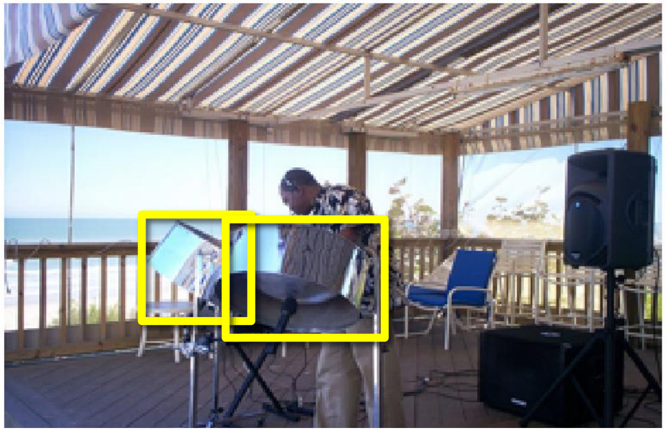
✓

Output



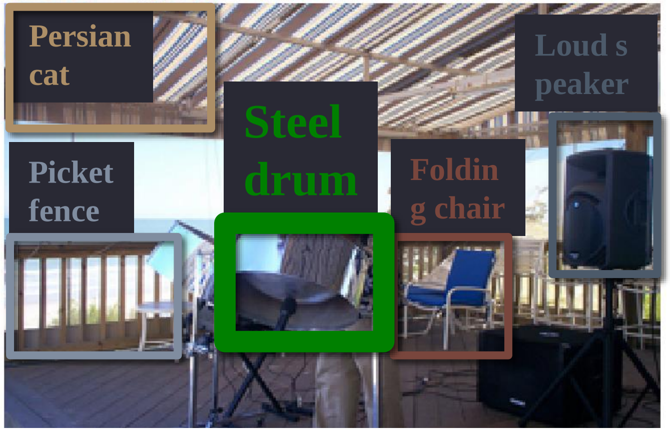
ILSVRC Task 2: Classification + Localization

Steel drum



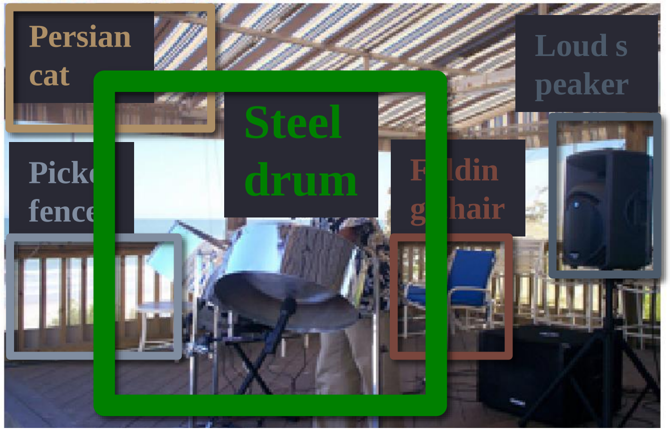
Output

✓



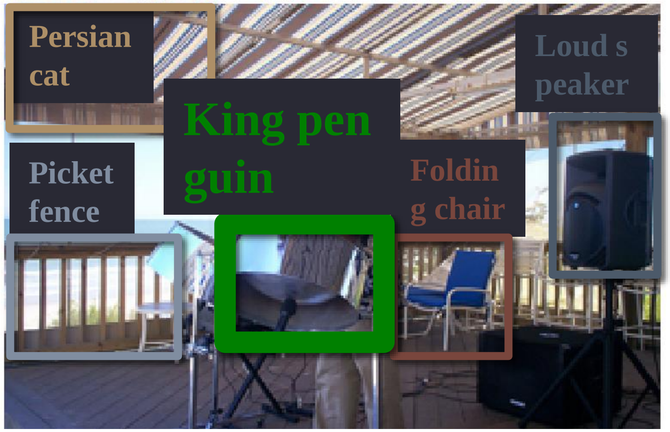
Output (bad localization)

✗



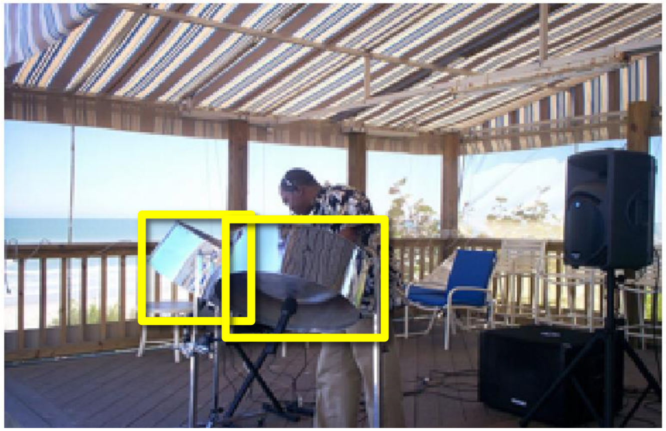
Output (bad classification)

✗



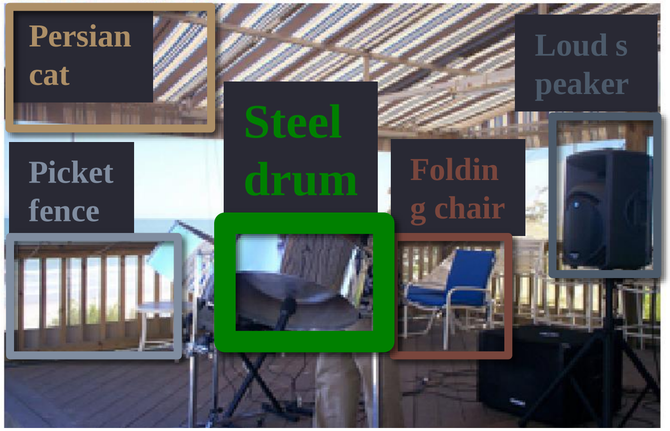
ILSVRC Task 2: Classification + Localization

Steel drum



Output

✔

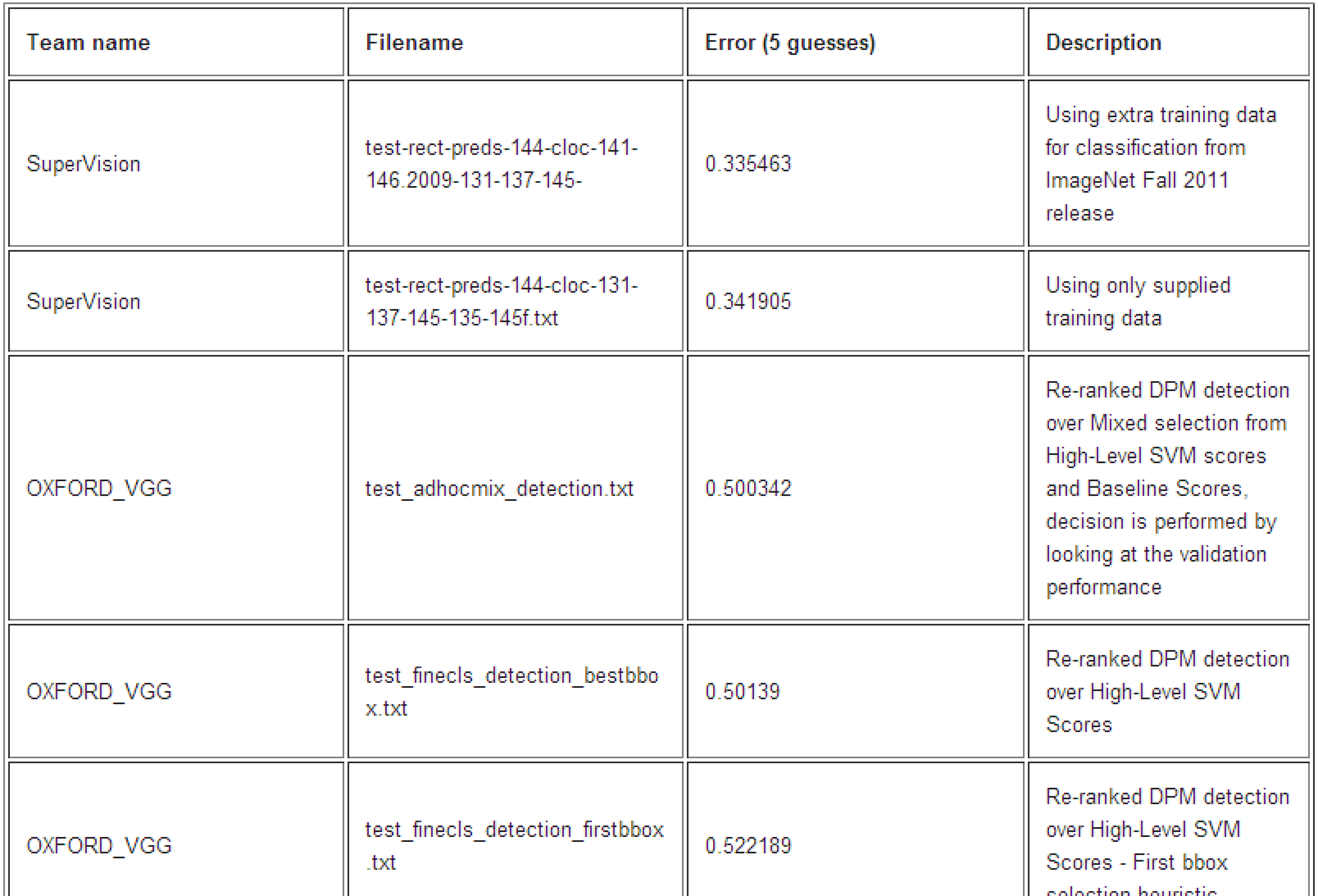


$$\text{Accuracy} = \frac{1}{N} \sum_{\text{N-images}} 1[\text{correct on image i}]$$

Classification: Comparison

Submission	Method	Error rate
SuperVision	Deep CNN	0.16422
ISI	FV: SIFT, LBP, GIST, CSIFT	0.26172
XRCE/INRIA	FV: SIFT and color 1M-dim features	0.27058
OXFORD_VGG	FV: SIFT and color 270K-dim features	0.27302

Classification + Localization



Team name	Filename	Error (5 guesses)	Description
SuperVision	test-rect-preds-144-cloc-141-146.2009-131-137-145-	0.335463	Using extra training data for classification from ImageNet Fall 2011 release
SuperVision	test-rect-preds-144-cloc-131-137-145-135-145f.txt	0.341905	Using only supplied training data
OXFORD_VGG	test_adhocmix_detection.txt	0.500342	Re-ranked DPM detection over Mixed selection from High-Level SVM scores and Baseline Scores, decision is performed by looking at the validation performance
OXFORD_VGG	test_finecls_detection_bestbbox.txt	0.50139	Re-ranked DPM detection over High-Level SVM Scores
OXFORD_VGG	test_finecls_detection_firstbbox.txt	0.522189	Re-ranked DPM detection over High-Level SVM Scores - First bbox selection heuristic

SuperVision (SV)

Image classification: Deep convolutional neural networks

- 7 hidden “weight” layers, 650K neurons, 60M parameters, 630M conn ections
- Rectified Linear Units, max pooling, dropout trick
- Randomly extracted 224x224 patches for more data
- Trained with SGD on two GPUs for a week, **fully supervised**

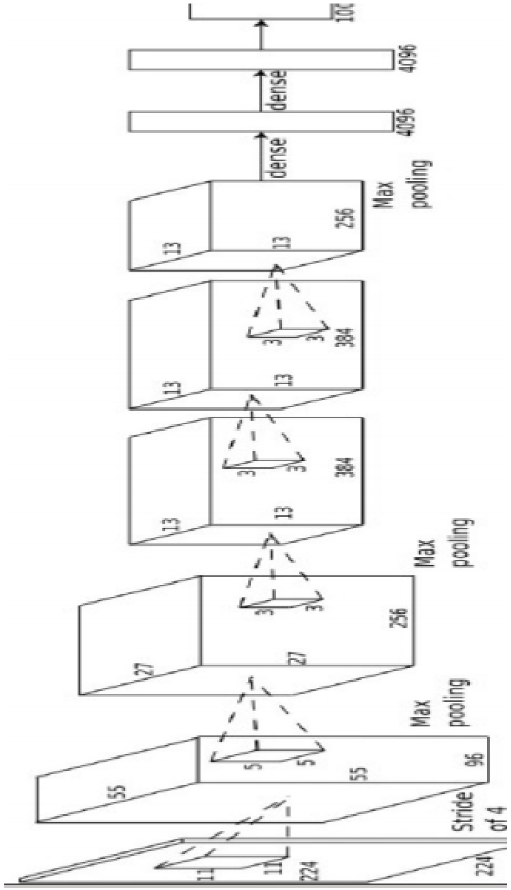
Localization: Regression on (x,y,w,h)

http://image-net.org/challenges/LSVRC/2012/supervision.pdf

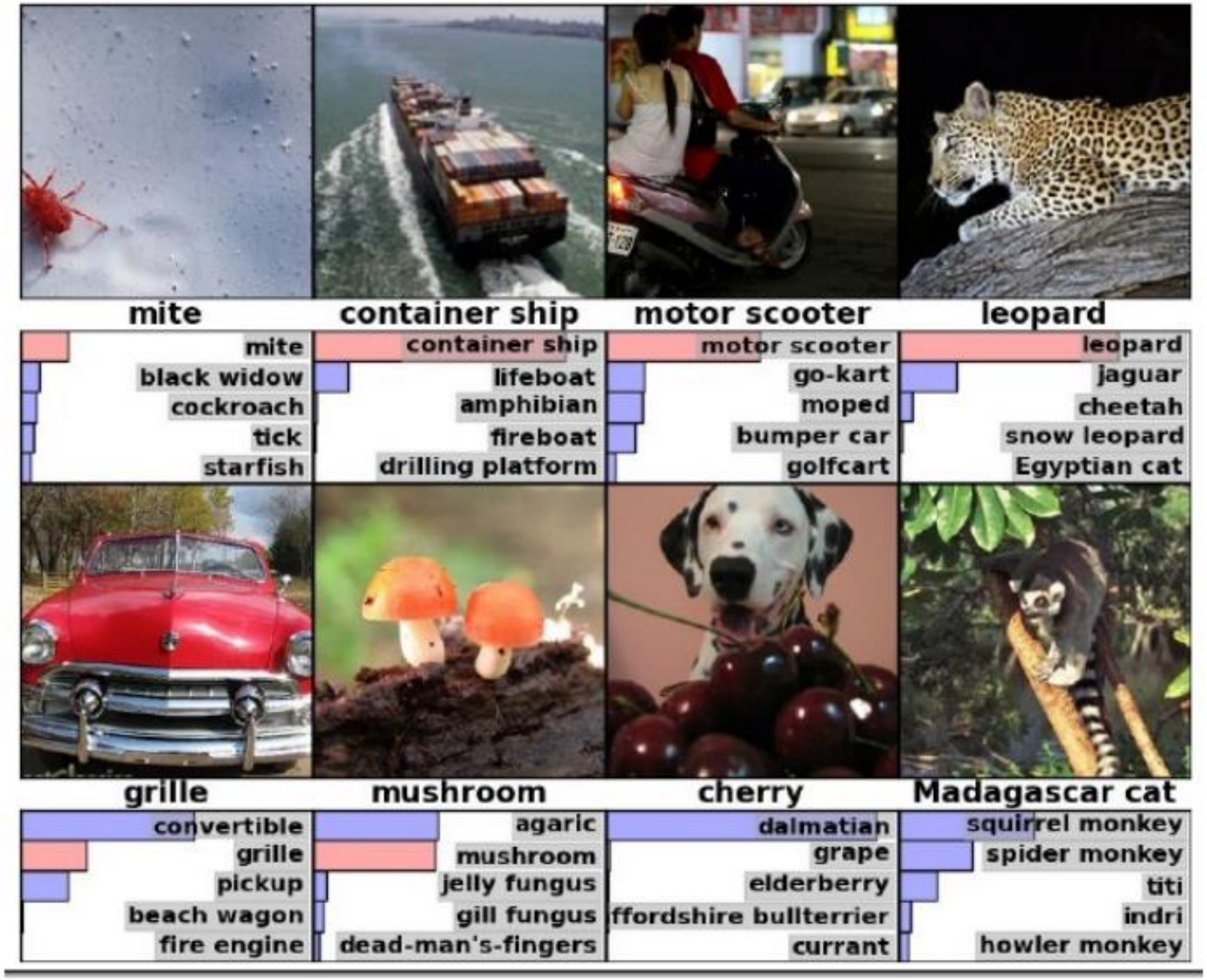
SuperVision

- Won the 2012 ImageNet LSVRC. 60 Million parameters, 832M MAC ops

4M	FULL CONNECT
16M	FULL 4096/ReLU
37M	FULL 4096/ReLU
	MAX POOLING
442K	CONV 3x3/ReLU 256fm
1.3M	CONV 3x3ReLU 384fm
884K	CONV 3x3/ReLU 384fm
	MAX POOLING 2x2sub
	LOCAL CONTRAST NORM
307K	CONV 11x11/ReLU 256fm
	MAX POOL 2x2sub
	LOCAL CONTRAST NORM
35K	CONV 11x11/ReLU 96fm



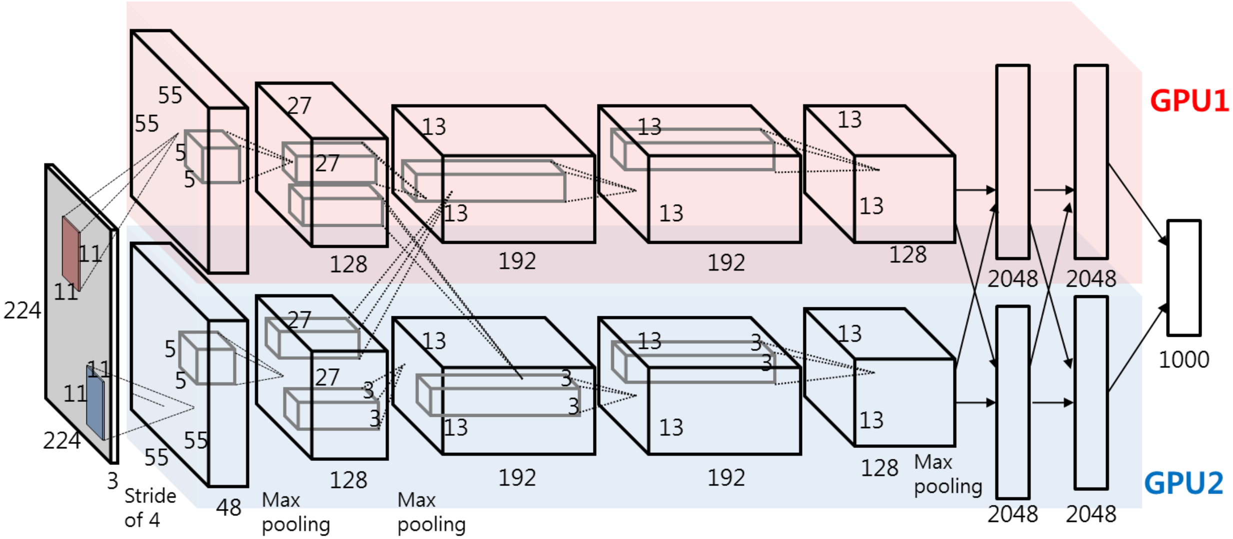
Object Recognition



ALEXNET

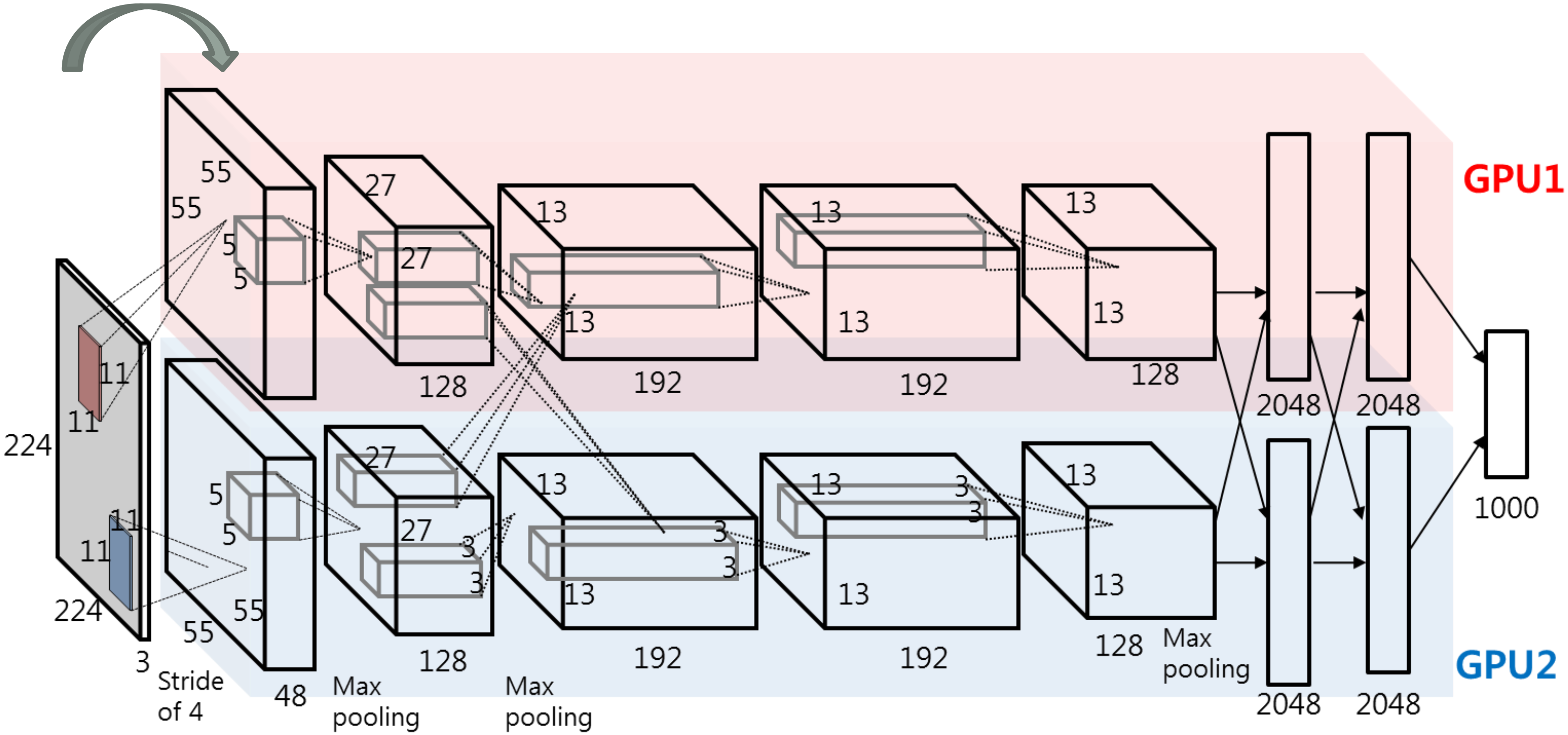
AlexNet

- AlexNet: won the 2012 ImageNet competition by making 40% less error than the next best competitor
  - It is composed of 5 convolutional layers
  - The input is a color RGB image
  - Computation is divided over 2 GPU architectures
  - Learning uses artificial data augmentation and connection drop-out to avoid over-fitting



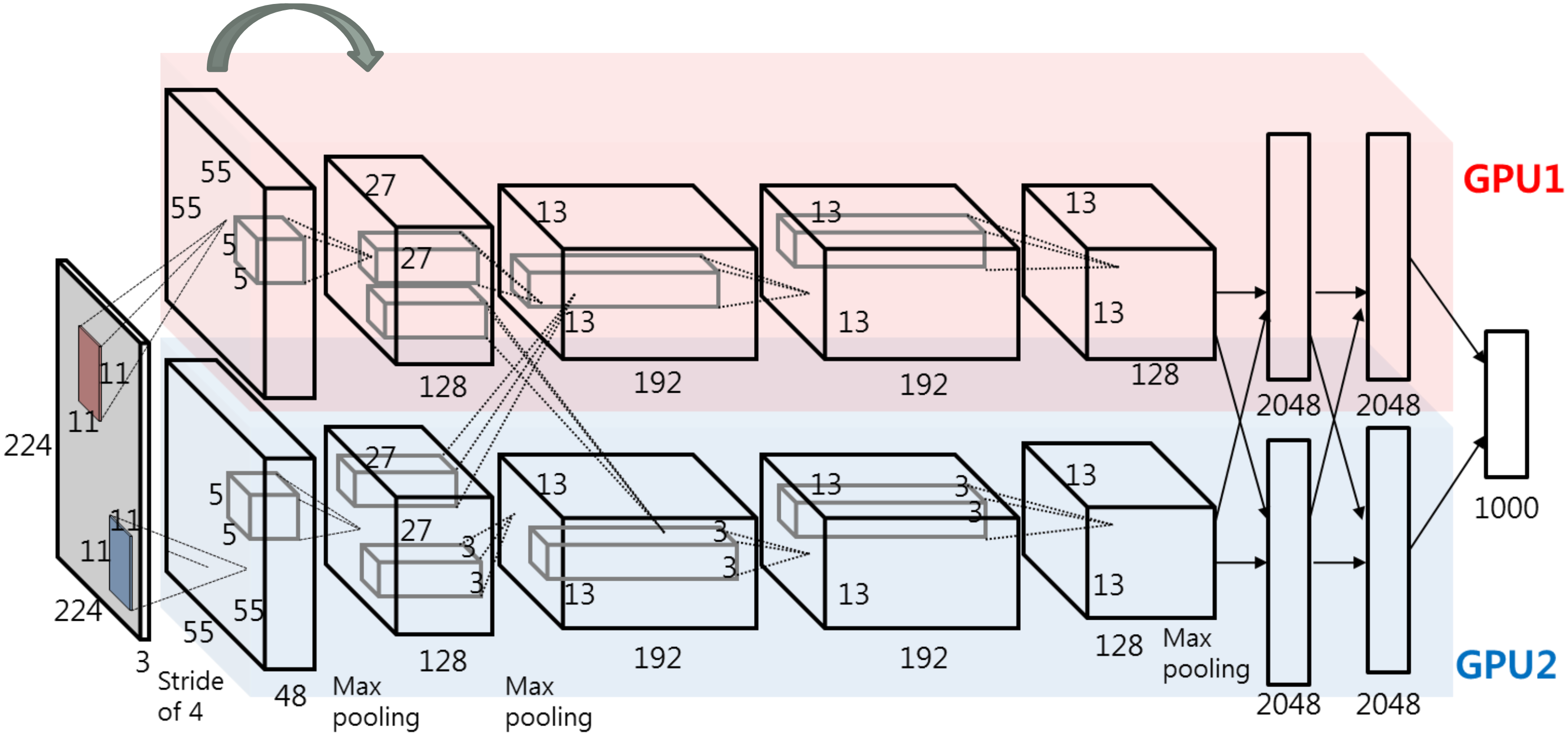
AlexNet in details

- The first layer applies 96 kernels of size 3x11x11
  - 34,848 parameters
  - Each kernel is applied with a stride of 4 pixels
  - (11x11x3)x(55x55x(48+48)) = 105,415,200 MACs



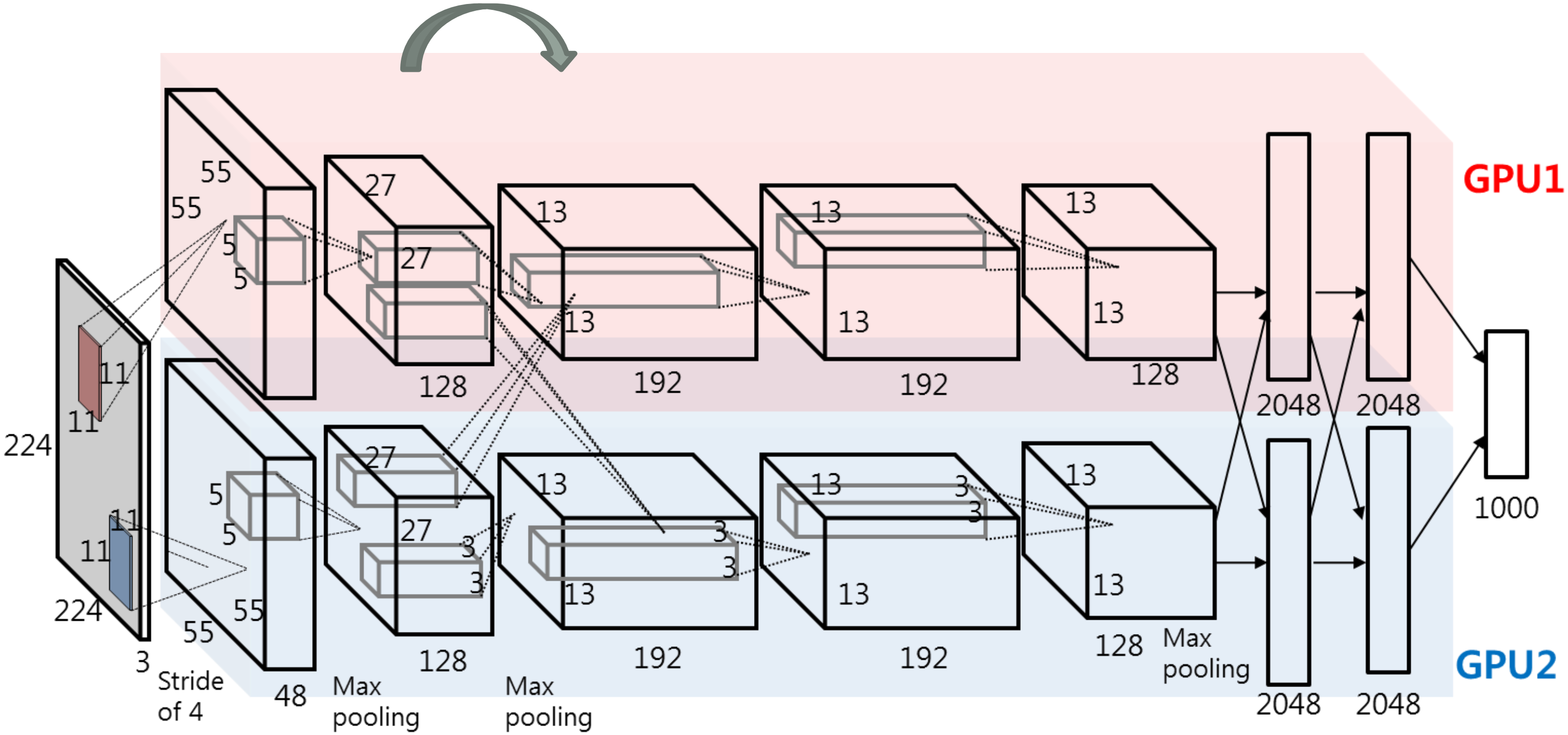
AlexNet in details

- The second layer applies 256 kernels of size 48x5x5
  - After applying a 3x3 max pooling with a stride of 2 pixels
  - 307,200 parameters
  - 256x(48x5x5)x(27x27)=223,948,800 MACs



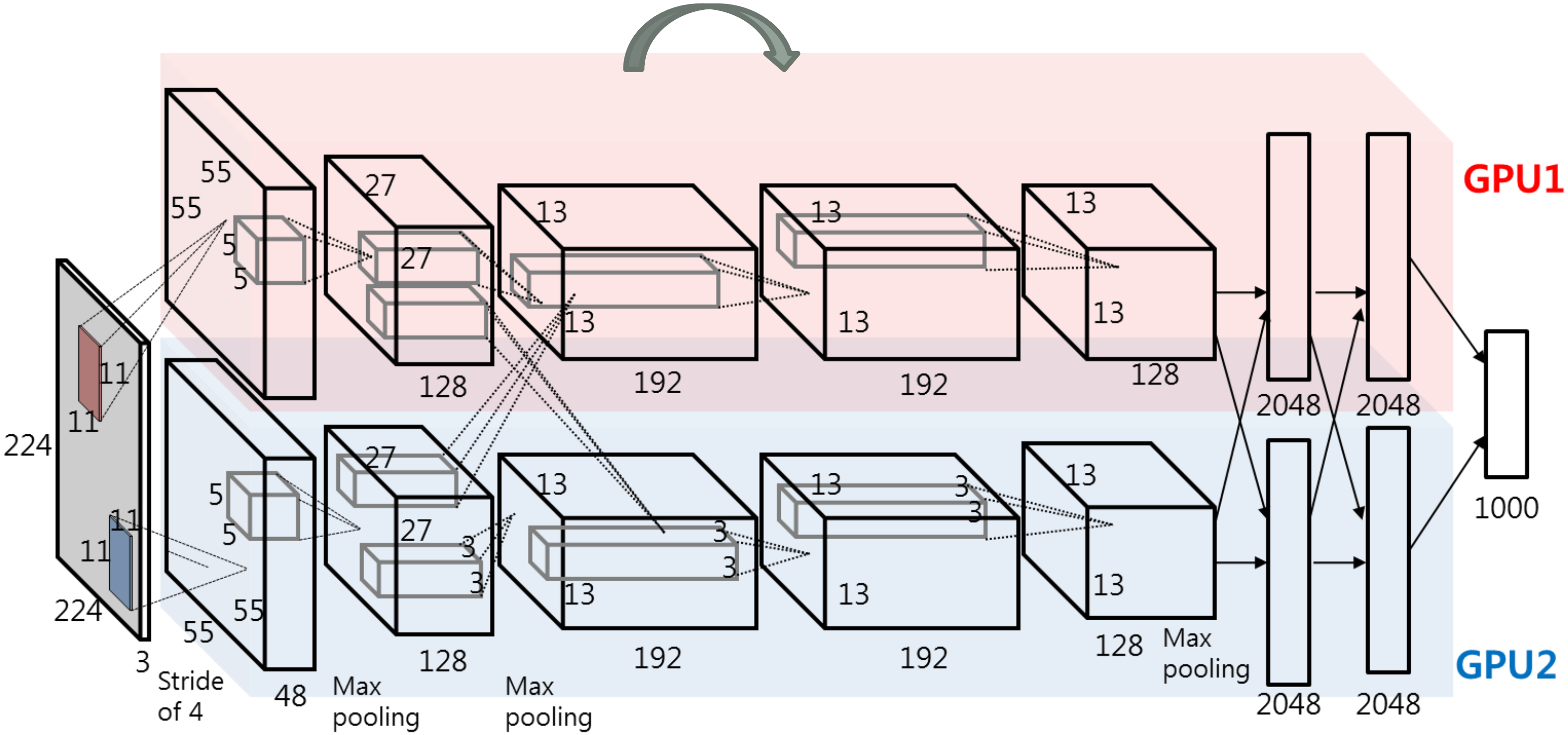
AlexNet in details

- The third layer applies 384 kernels of size 256x3x3
  - After applying a 3x3 max pooling with a stride of 2 pixels
  - 884,736 parameters
  - 384x((128+128)x3x3)x(13x13)=149,520,384 MACs



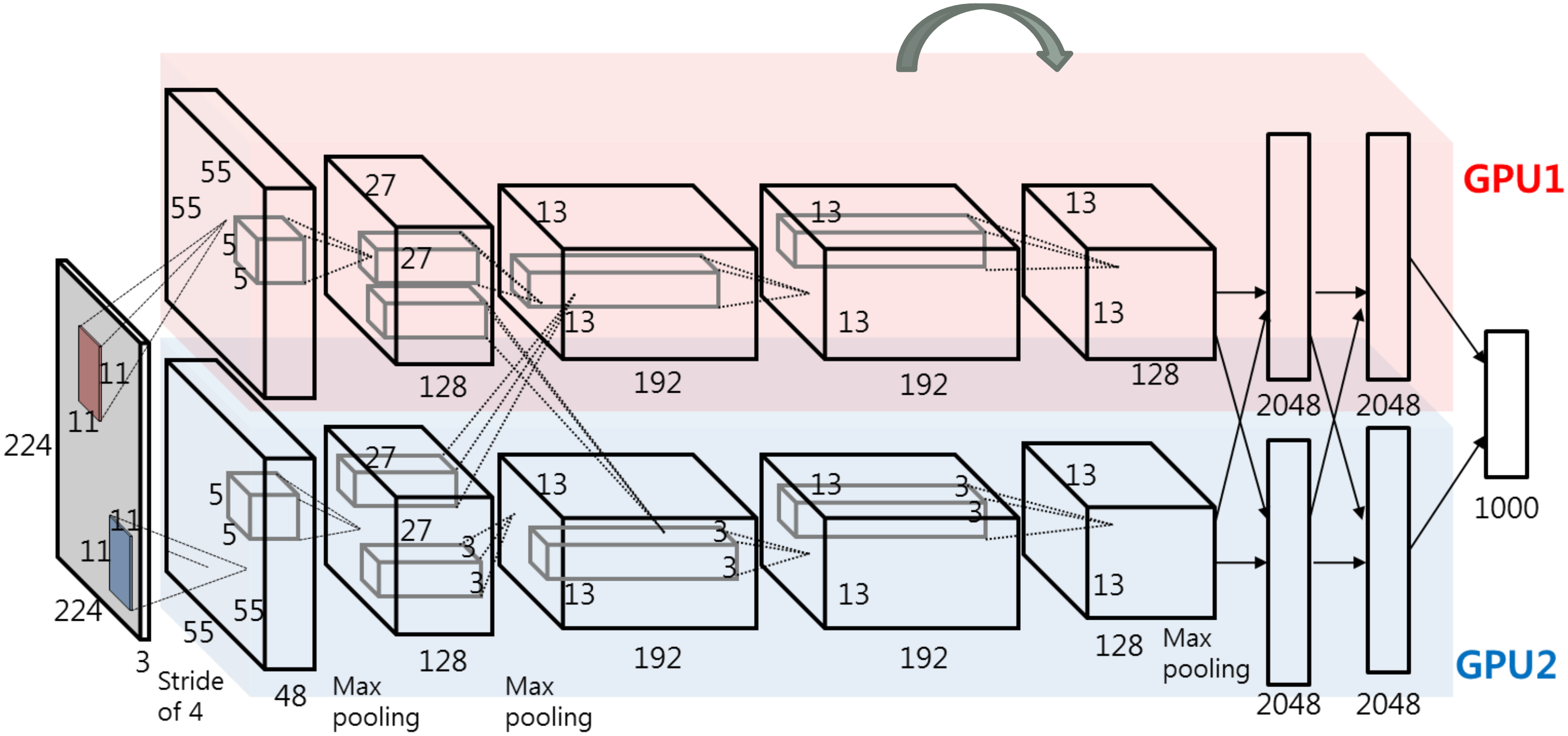
AlexNet in details

- The fourth layer applies 384 kernels of size 192x3x3
  - Without pooling
  - 663,552 parameters
  - 384x(192x3x3)x(13x13)=112,140,288 MACs



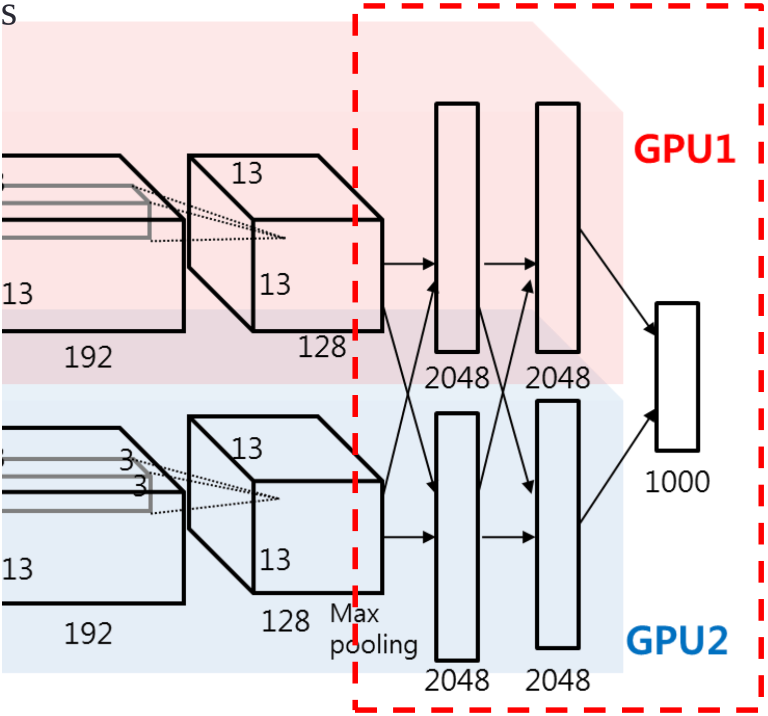
AlexNet in details

- The fifth layer applies 256 kernels of size 192x3x3
    - Without pooling
    - 442,368 parameters
    - 256x(192x3x3)x(13x13)=74,760,192 MACs



AlexNet in details

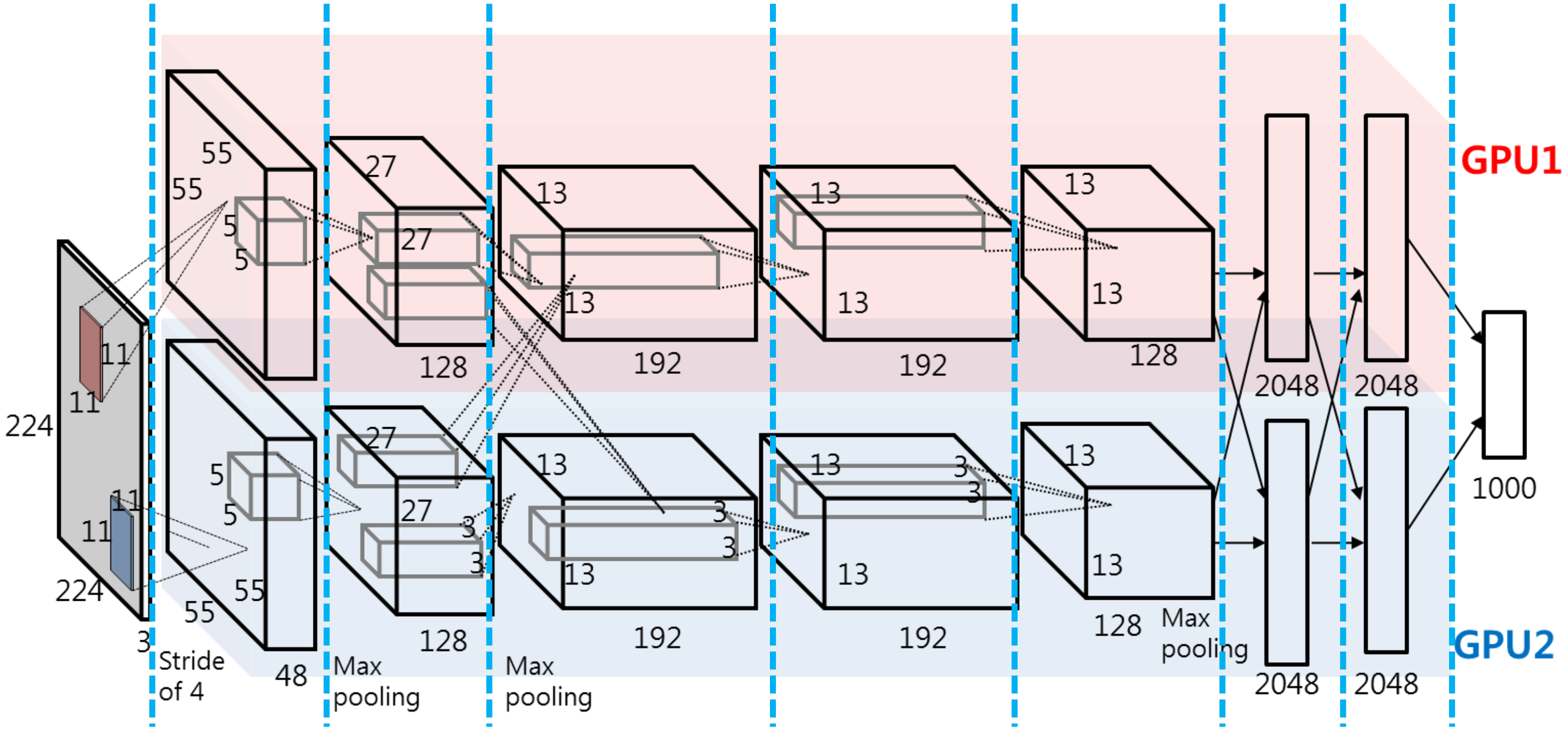
- The output of the fifth layer (after a 3x3 max pooling with a stride of 2 pixels) is connected to a fully connected 3-layer perceptron
  - 1st layer
    - (2x6x6x128)x4096= 37,748,736connections
  - 2nd layer
    - 4096x4096= 16,777,216 connections
  - 3rd layer
    - 4096x1000= 4,096,000 connections



AlexNet in details

- 60 Million parameters, 832M MAC ops

Parameters: 35K 307K 884K 653K 442K 37M 16M 4M



MAC ops: 105M 223M 149M 112M 74M 37M 16M 4M

BACKUPS

Complexity of a CNN classifier

- Apply the filter bank
  - Each input image of size MxM is convoluted with K kernels each of size NxN
    - KxMxMxNxN MAC operations
- Applying the non-linearity
  - usually done through look-up tables
- Performing pooling
  - Pooling aggregates the values of a VxV regions by applying an average or a max operation
  - The image is subsampled by applying the pooling every P pixels
  - (MxM)/(PxP) pooling operations over sets of size VxV
- Each fully connected layer of a perceptron involves L_ixL_o MAC operations where L is the number of neurons (in input and output layers)