

# Deep Learning

Лекции в computer science клубе

Санкт-Петербург, лето 2016

# Структура курса

- Занятие 1. (Дмитрий Кропотов) Стохастическая оптимизация, автоматическое дифференцирование
- Занятие 2. (Алексей Артёмов) Свёрточные нейронные сети, библиотеки для работы с нейросетями
  - Домашнее задание 1
- Занятие 3. (Екатерина Лобачёва) Рекуррентные нейронные сети.
  - Домашнее задание 2
- Занятие 4. (Дмитрий Ветров) Нейробайесовские модели

<http://compsciclub.ru/courses/deep-learning/2016-summer/>

# ImageNet (image-net.org)

## Soccer, association football

A football game in which two teams of 11 players try to kick or head a ball into the opponents' goal

1395 pictures

90.76% Popularity Percentile



Numbers in brackets: (the number of synsets in the subtree).

- ImageNet 2011 Fall Release (32326)
  - plant, flora, plant life (4486)
  - geological formation, formation (1)
  - natural object (1112)
  - sport, athletics (176)
    - rowing, row (2)
    - funambulism, tightrope walking
    - judo (0)
    - blood sport (10)
    - gymnastics, gymnastic exercise
    - water sport, aquatics (19)
    - track and field (5)
    - outdoor sport, field sport (17)
    - contact sport (18)
      - boxing, pugilism, fisticuffs (
      - wrestling, rassling, grapplir
      - ice hockey, hockey, hockey
      - football, football game (5)
      - rugby, rugby football, rug
      - professional football (0)
      - American football, Amer
      - soccer, association foot
    - team sport (0)
    - racing (7)
    - athletic game (70)
    - riding, horseback riding, equite
    - archery (0)
    - cycling (3)
    - sledding (3)
    - skating (6)

Treemap Visualization

Images of the Synset

Downloads

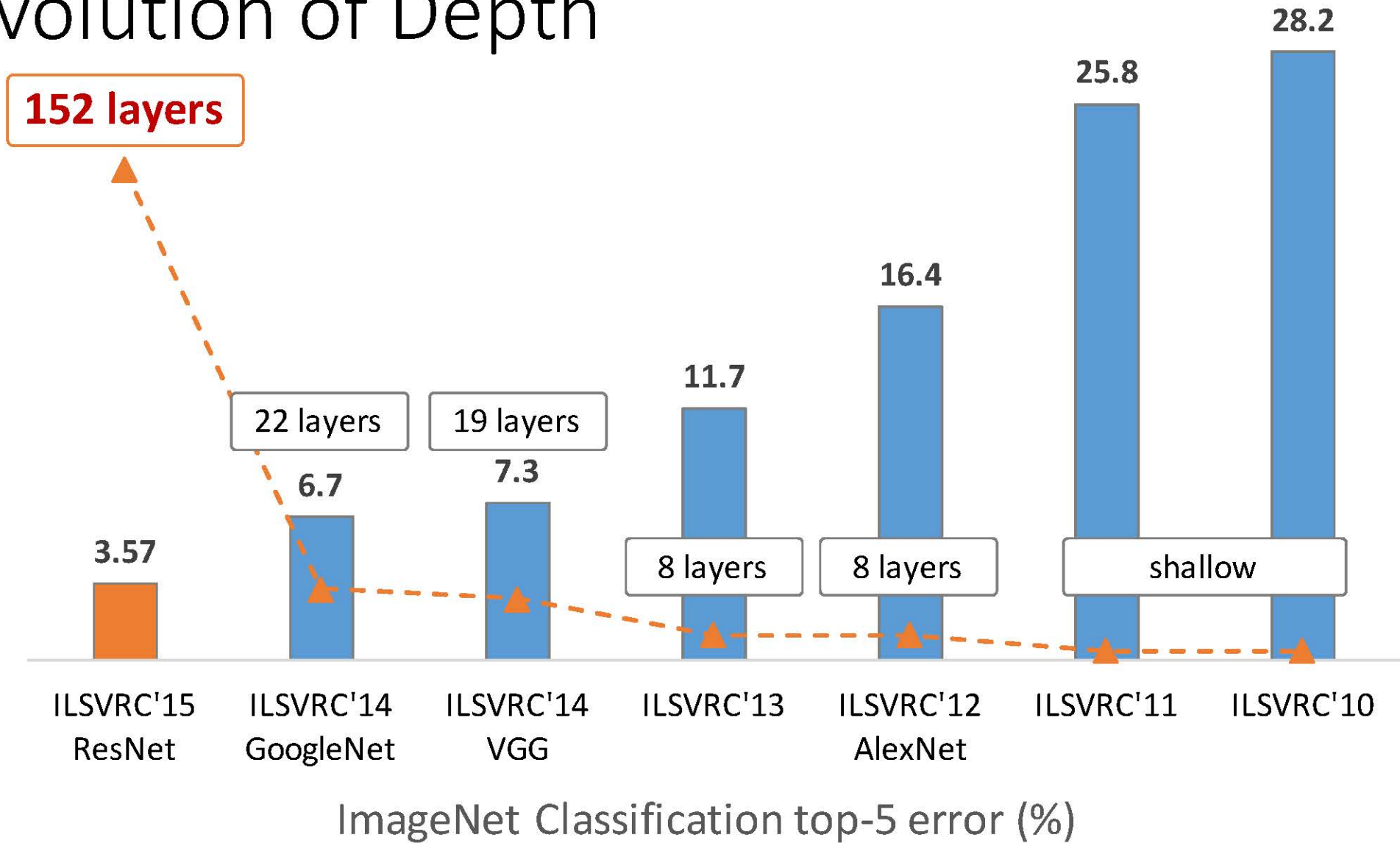


<sup>4</sup>Images of children synsets are not included. All images shown are thumbnails. Images may be subject to copyright.

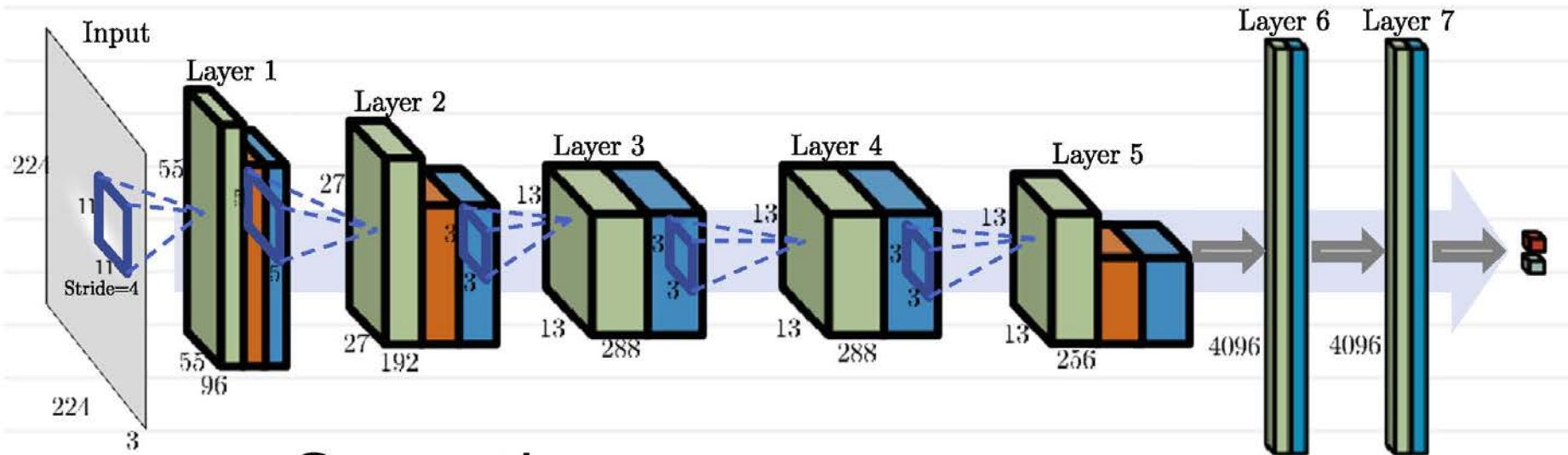
Prev 1 2 3 4 5 6 7 8 9 10 ... 39 40 Next

14,197,122 изображений  
21841 категорий

# Revolution of Depth



# AlexNet: свёрточная нейронная сеть



Operations:

generalized convolutions

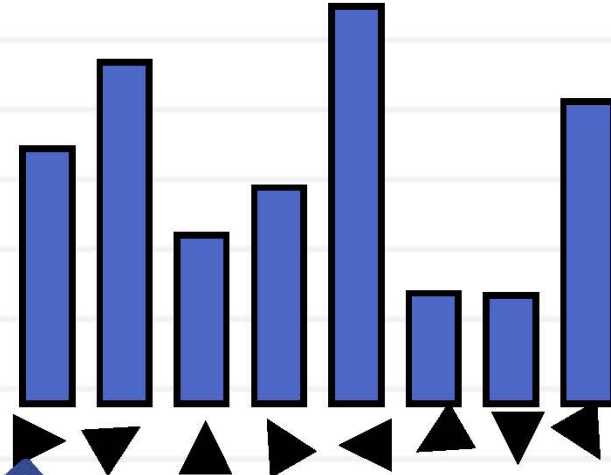
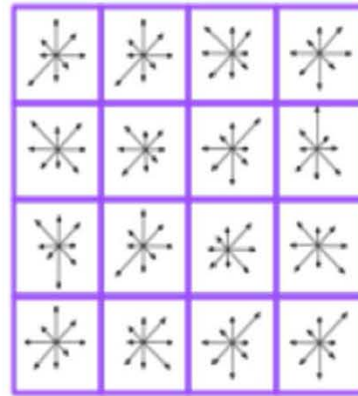
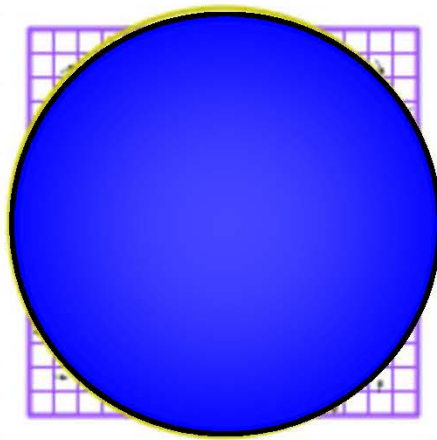
pooling (image resizing)

elementwise non-linearity

matrix multiplication

# 12 лет назад: дескриптор SIFT

SIFT – “scale invariant feature transform”



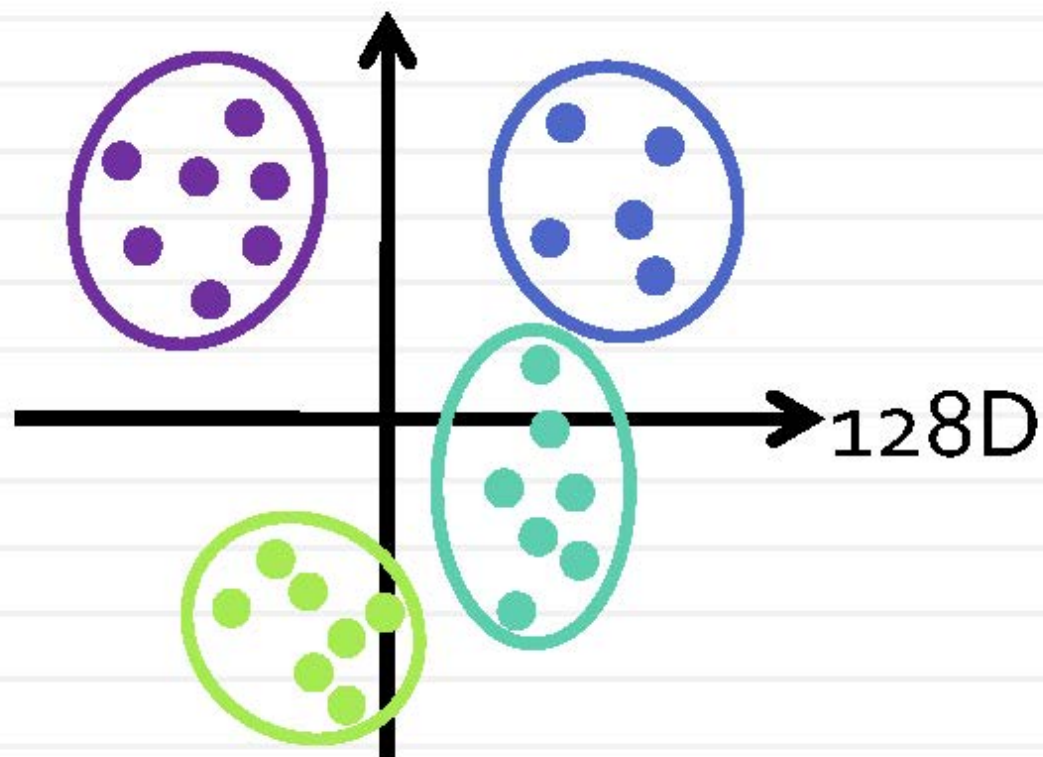
=> Feature vector  
(128D)

D. Lowe. Distinctive Image Features from Scale-invariant Keypoints, 2004.

# 12 лет назад: мешок слов

VideoGoogle

Sivic & Zisserman, ICCV 2003

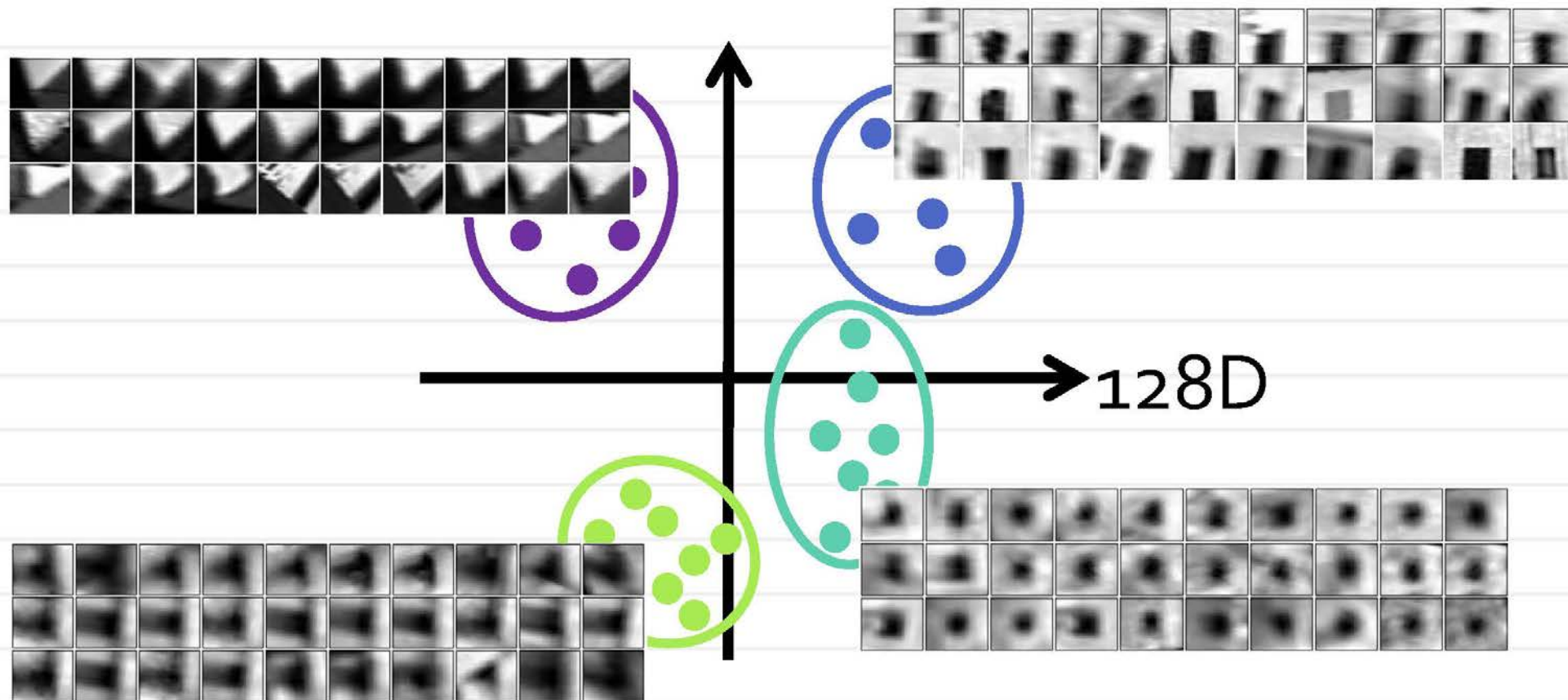




# 12 лет назад: мешок слов

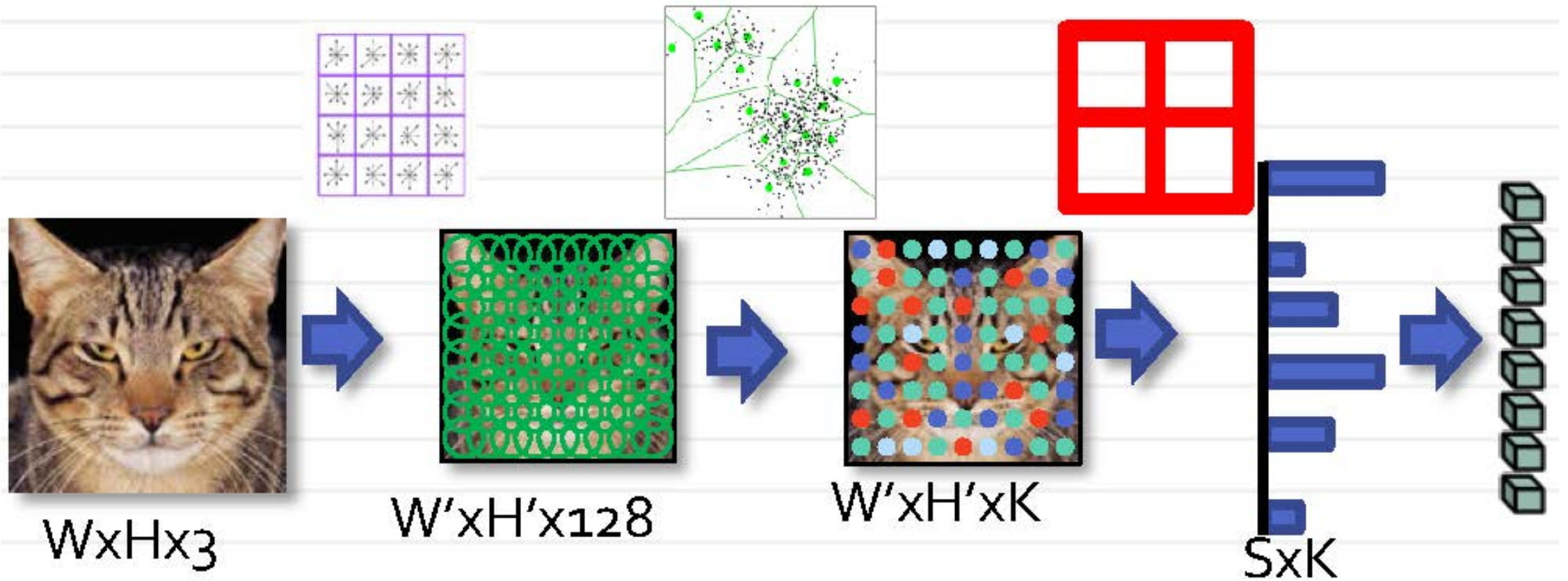
VideoGoogle

Sivic & Zisserman, ICCV 2003

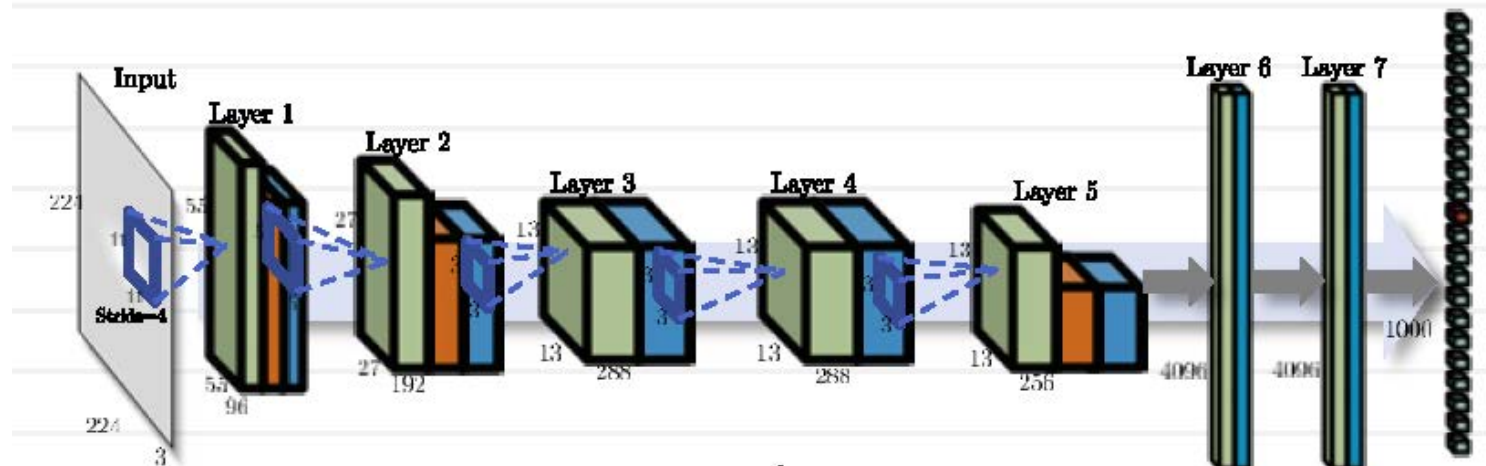
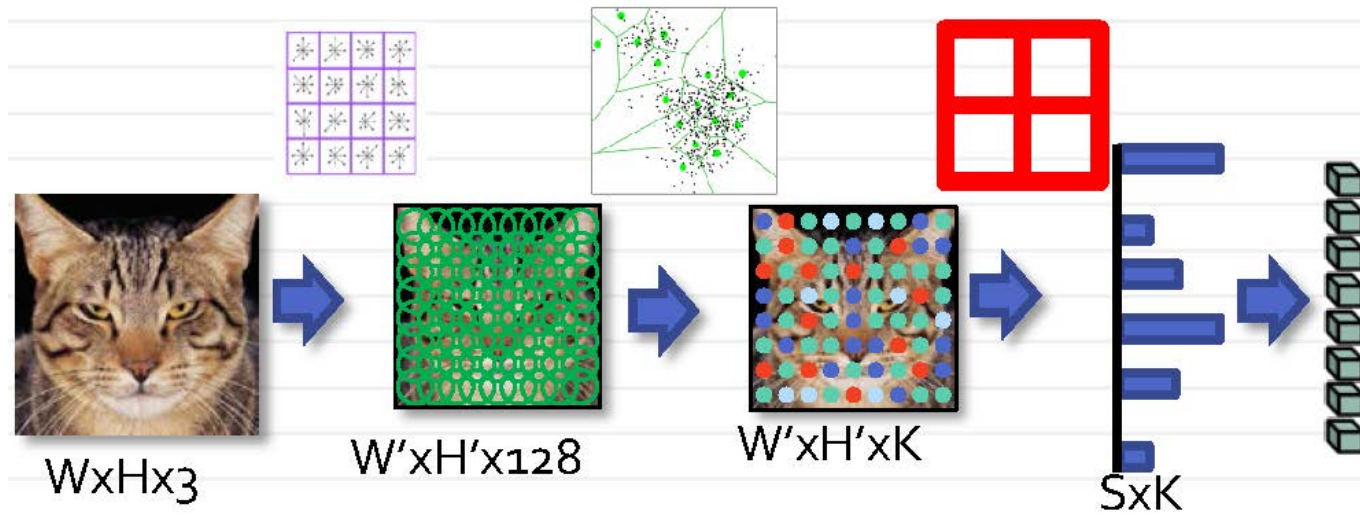




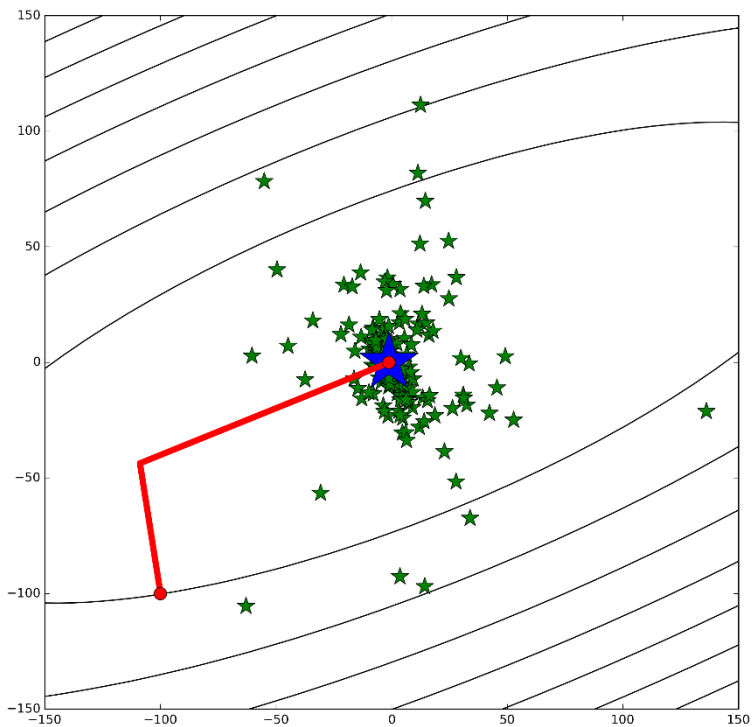
# 12 лет назад: SIFT + мешок слов + классификатор



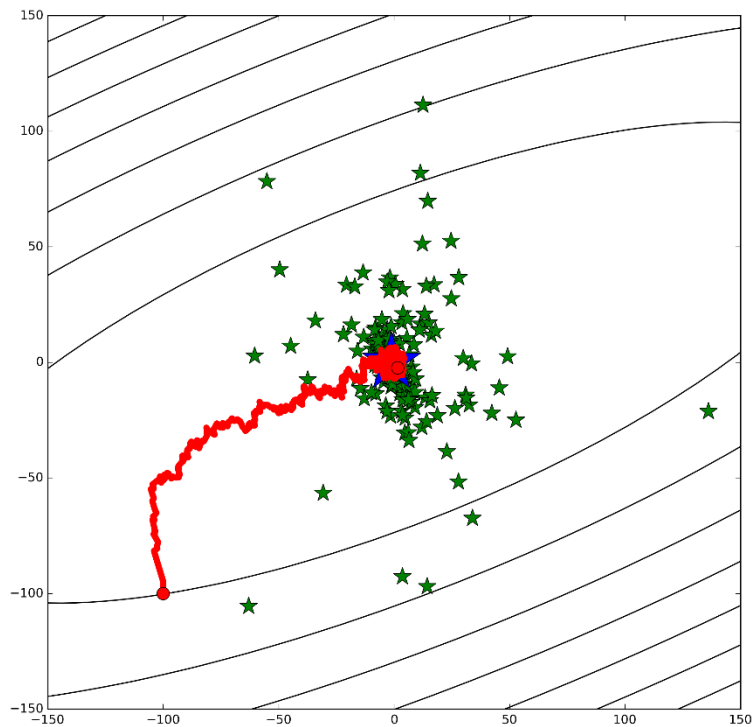
# CNN vs. SIFT+мешок слов+классификатор



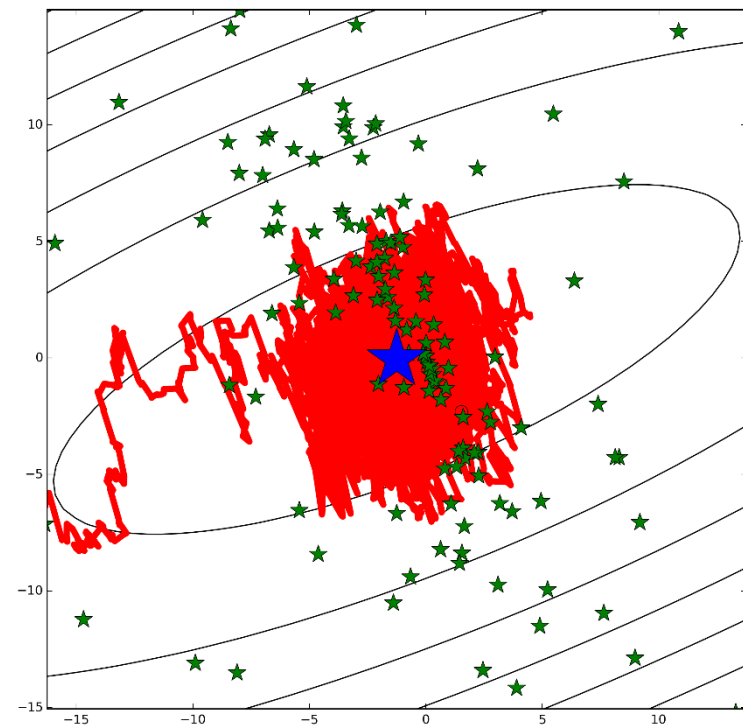
# GD vs. SGD



Град. спуск

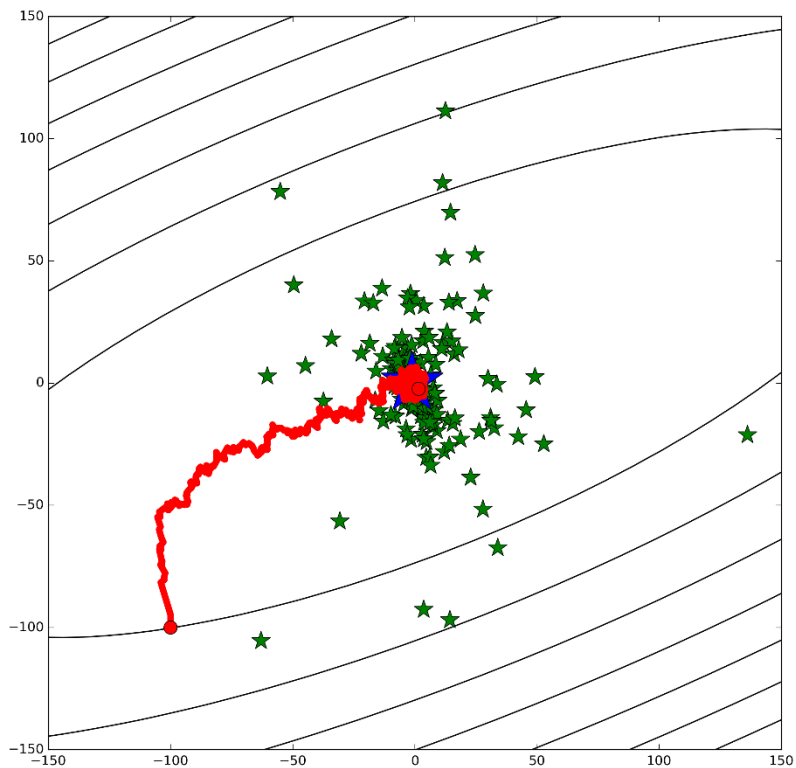


Стох. град. спуск

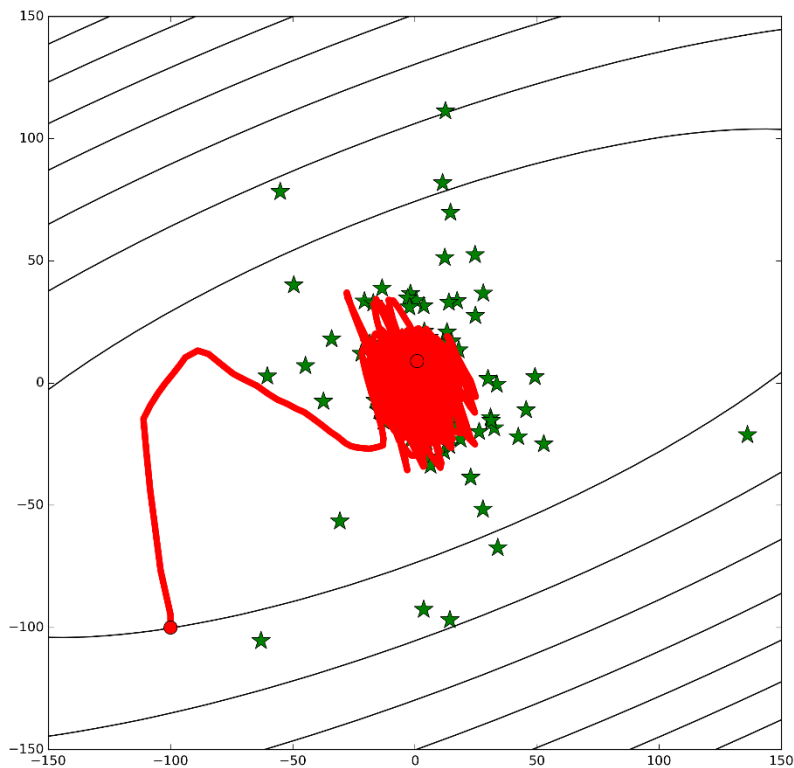


Стох. град. спуск  
в окрестности оптимума

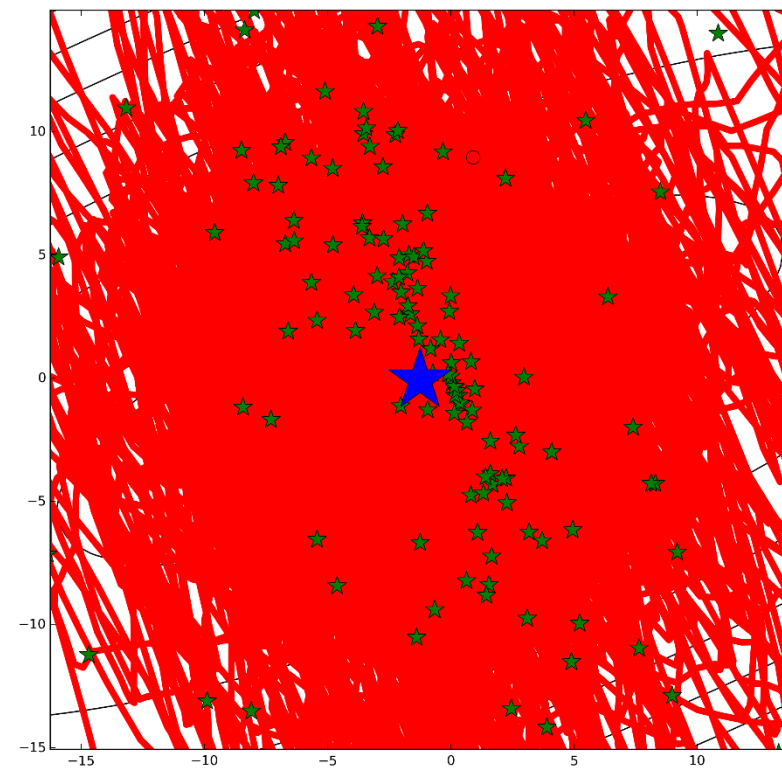
# SGD vs. SGD+mom



Стох. град. спуск

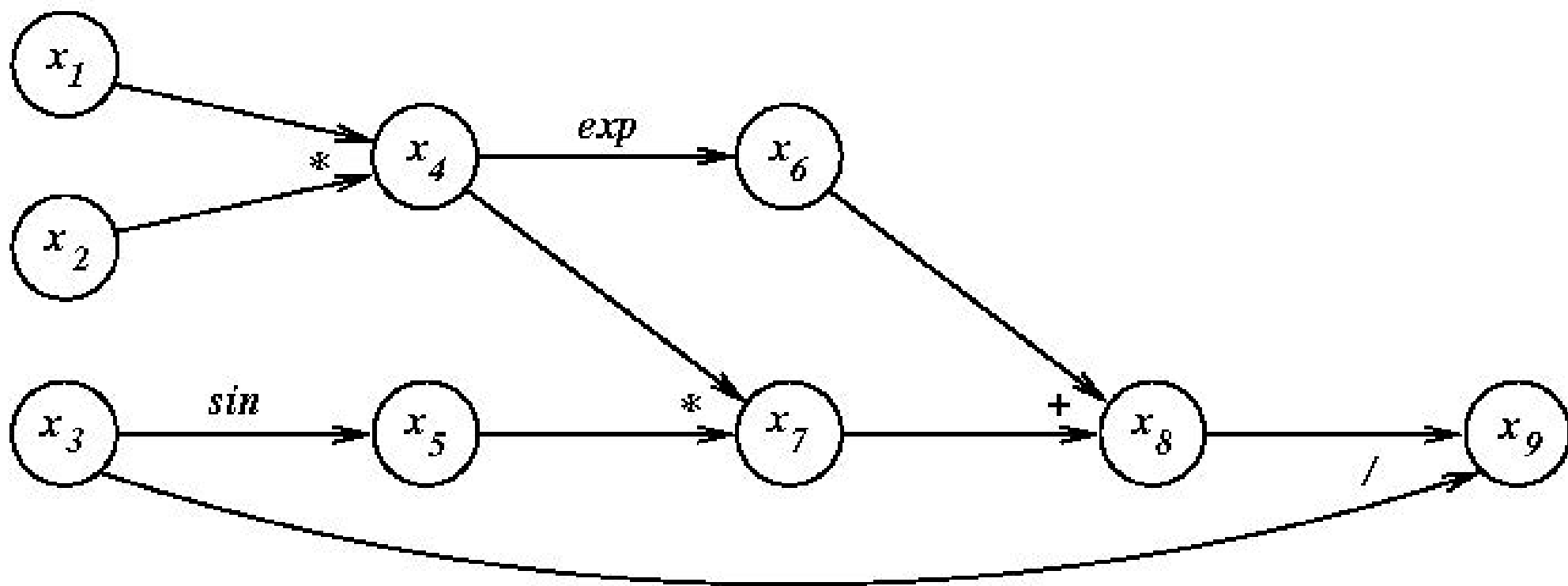


Стох. град. спуск  
+ моментум



Стох. град. спуск  
+ моментум  
в окрестности оптимума

$$f(x) = (x_1 x_2 \sin x_3 + e^{x_1 x_2}) / x_3.$$



# Batch normalization

**Input:** Values of  $x$  over a mini-batch:  $\mathcal{B} = \{x_{1\dots m}\}$ ;  
Parameters to be learned:  $\gamma, \beta$

**Output:**  $\{y_i = \text{BN}_{\gamma,\beta}(x_i)\}$

$$\mu_{\mathcal{B}} \leftarrow \frac{1}{m} \sum_{i=1}^m x_i \quad // \text{ mini-batch mean}$$

$$\sigma_{\mathcal{B}}^2 \leftarrow \frac{1}{m} \sum_{i=1}^m (x_i - \mu_{\mathcal{B}})^2 \quad // \text{ mini-batch variance}$$

$$\hat{x}_i \leftarrow \frac{x_i - \mu_{\mathcal{B}}}{\sqrt{\sigma_{\mathcal{B}}^2 + \epsilon}} \quad // \text{ normalize}$$

$$y_i \leftarrow \gamma \hat{x}_i + \beta \equiv \text{BN}_{\gamma,\beta}(x_i) \quad // \text{ scale and shift}$$



# Литература

- [deeplearningbook.org](http://deeplearningbook.org) – основная книга по Deep Learning
- J. Nocedal, S. Wright. Numerical Optimization, 2006 – лучшая книга по классической оптимизации, в ней также рассматривается автоматическое дифференцирование
- M. Schmidt. Notes on Big-n Problems – обзор методов стохастической оптимизации