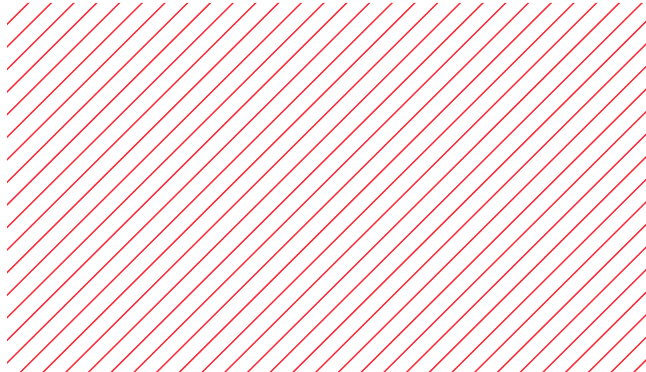
академия больших данных

mail.ru group

Анализ видео

Андрей Бояров

Ведущий инженер-исследователь, команда машинного зрения



План лекции

- Зачем обрабатывать и анализировать видео
- Отличия анализа видео с помощью DL от анализа изображений
- Основные задачи анализа видео
- Методы для решения этих задач
- Нахождение хайлайтов

Роль видео

55%
of people watch videos online every day

3.7 Billion
daily views for video at facebook

500 Million
hours of videos watched daily in Youtube

30%
video ad spend increased 30% from 2015 to 2016

2.6 X
people spend 2.6x more time on pages w/ video than w/o

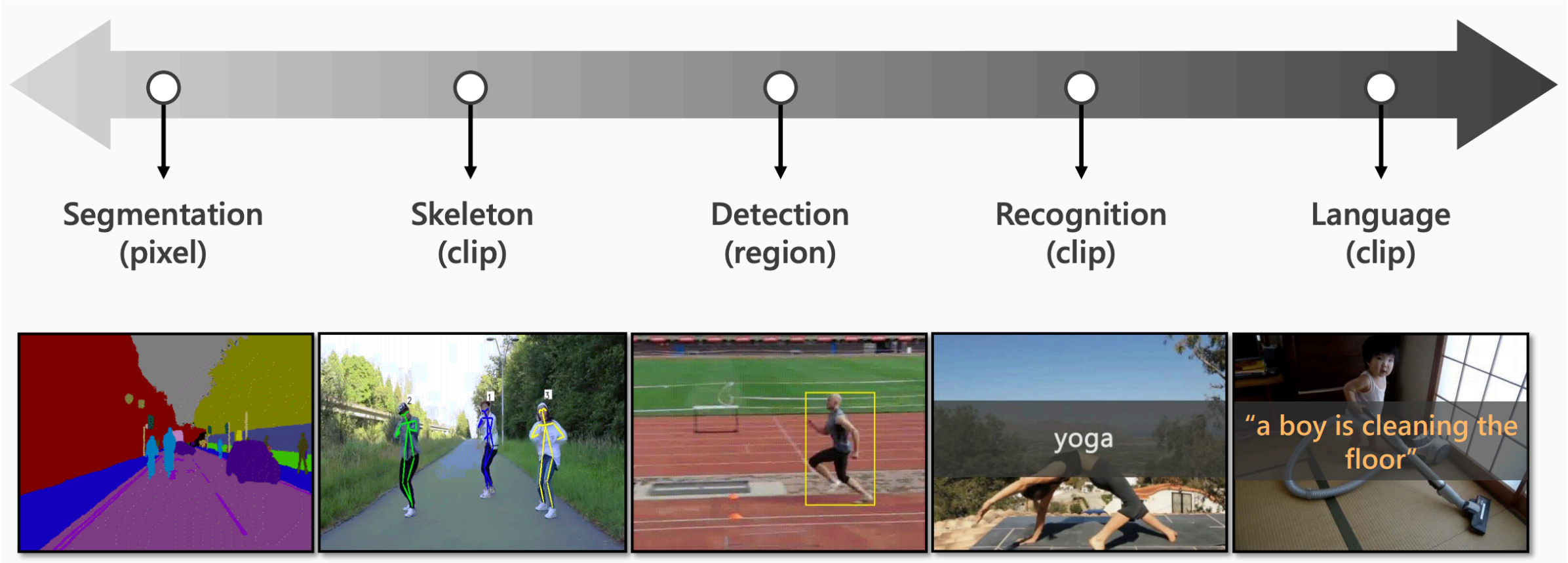
1200%
video generates 1200% more shares than text and image

Сложности обработки видео

- Видео делится на большое количество кадров (фреймов)
  - Больше времени на обработку
  - Больше места для хранения
- Важно учитывать временные (temporal) связи между фреймами
- У видео есть звук

«Понимание» видео

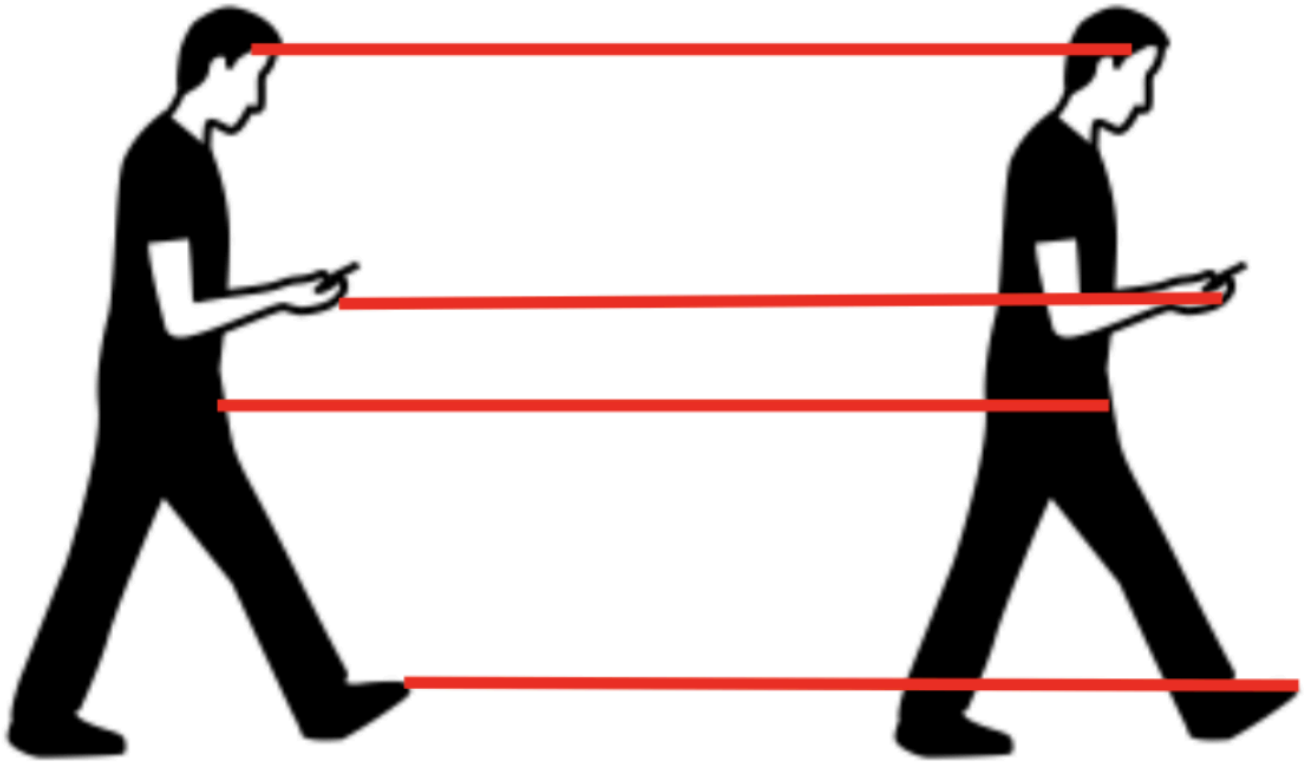
«Понимание» видео: основные задачи



Object tracking

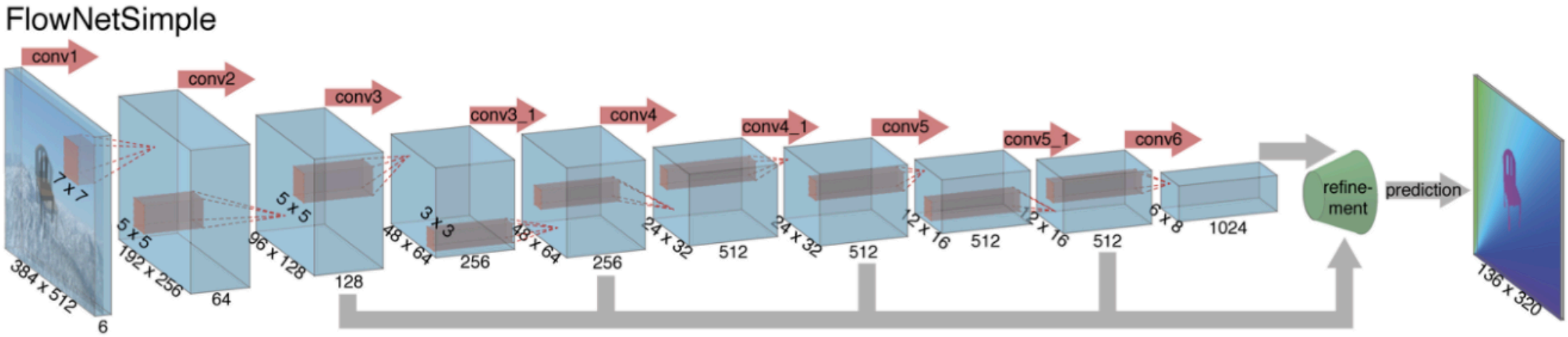
Optical flow

Вычисление сдвига между пикселями между двумя фреймами



Frame 0 — Frame 1

FlowNet



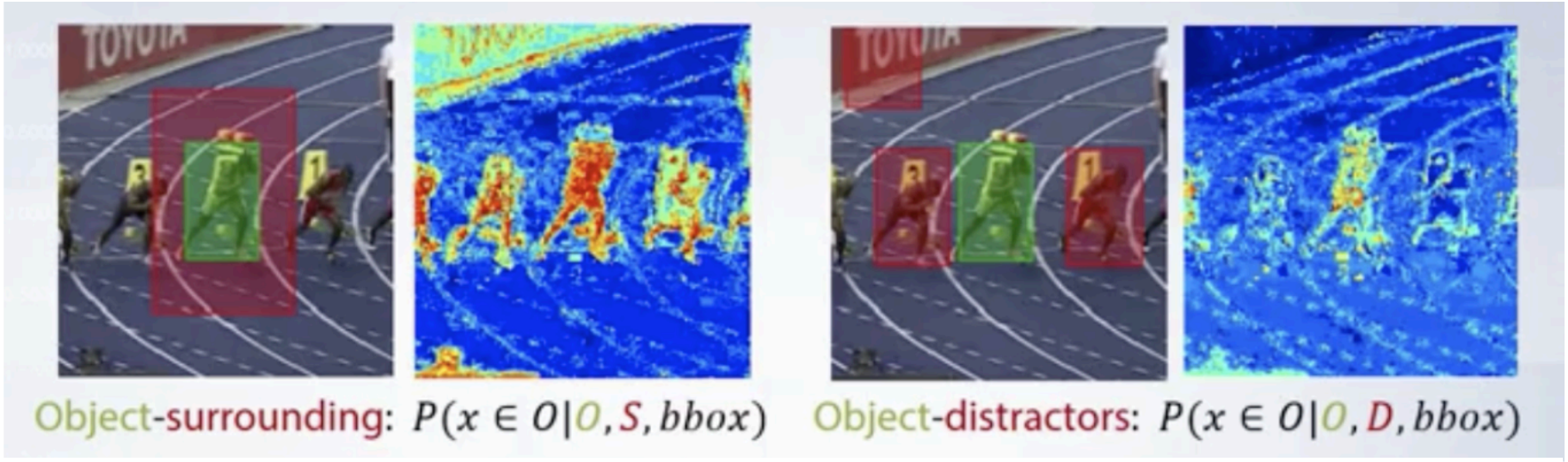
Принимает на вход два RGB изображения -> 3 + 3 каналов

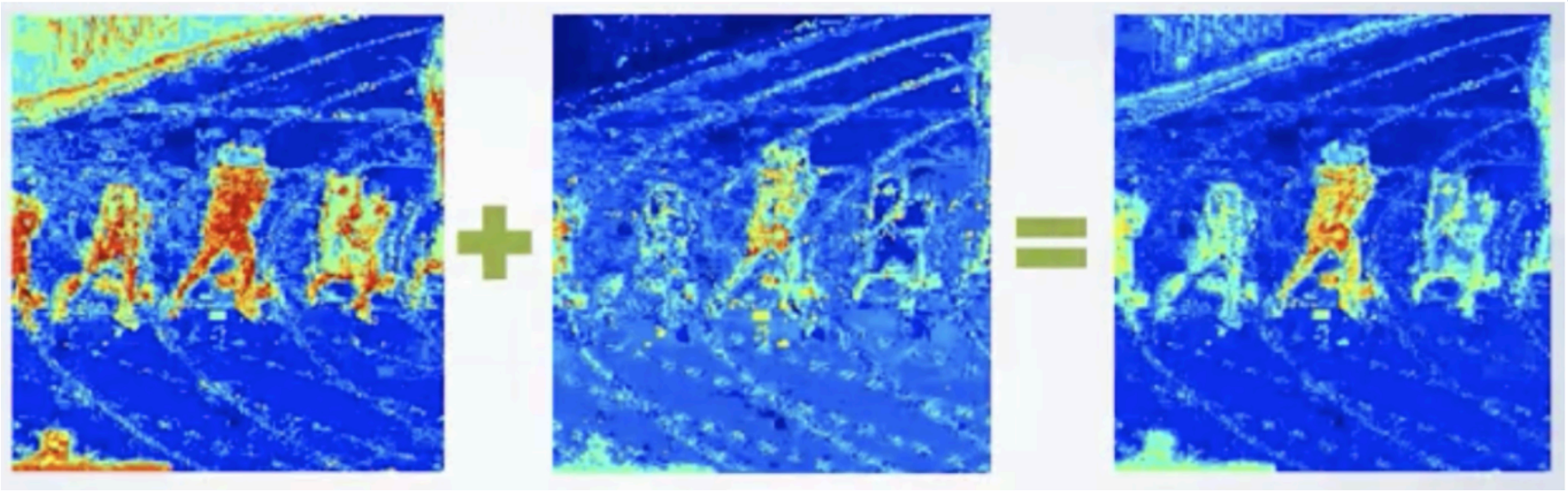
FlowNet: Learning Optical Flow with Convolutional Networks, [Fischer, 2015]

Visual object tracking

1. Детектируем объект для трекинга
2. Вычисляем его гистограмму цветов
3. Вычисляем цвет фона вокруг объекта
4. Удаляем цвет объекта из всего изображения
5. Получаем основанный на цвете трекер

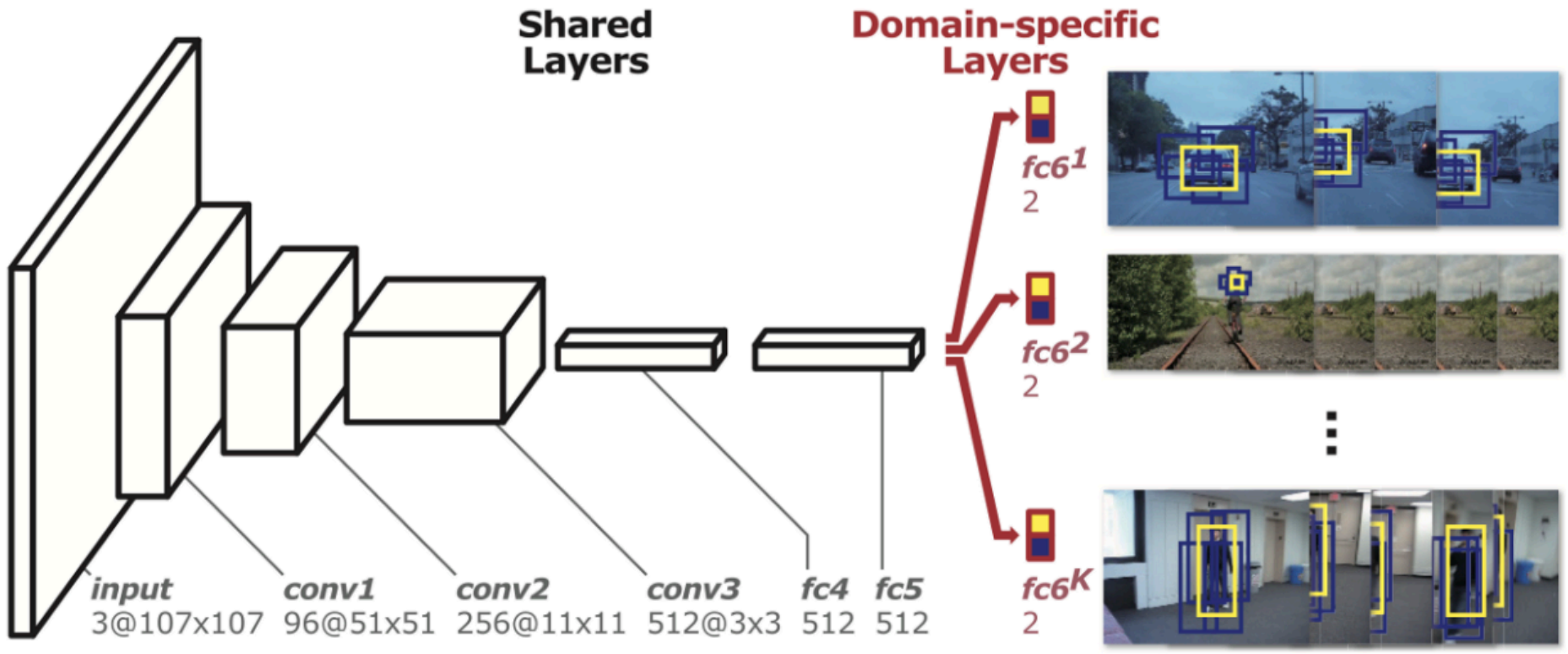
Visual object tracking





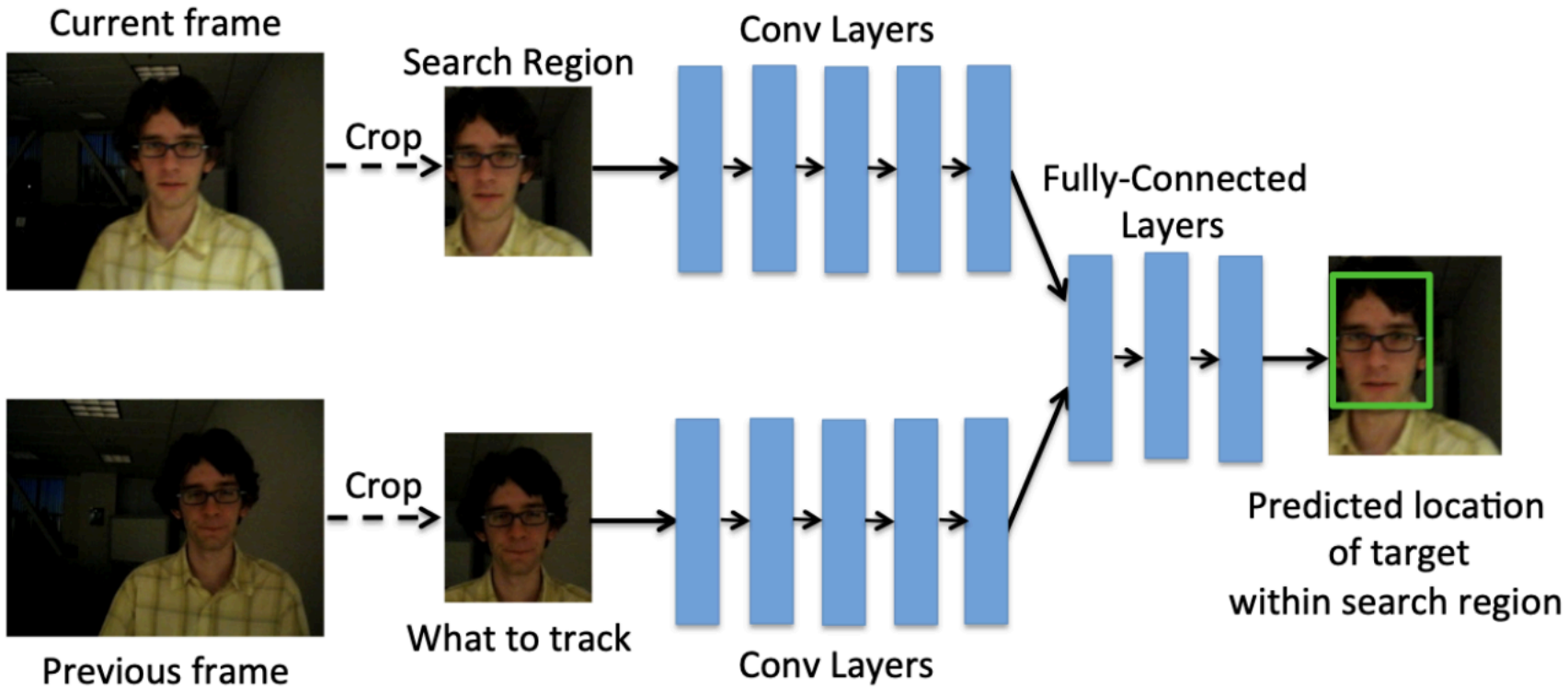
Multi-Domain Net

Детектирует объекты и фон



Learning Multi-Domain Convolutional Neural Networks for Visual Tracking [Nam, 2015]

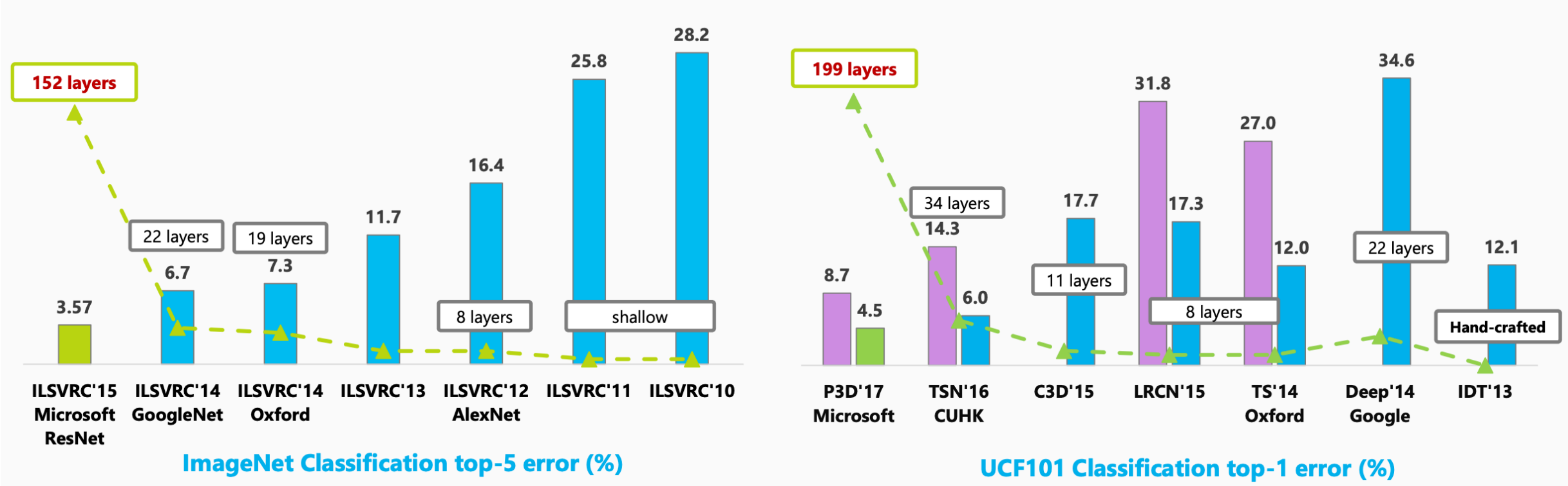
GOTURN (Generic Object Tracking Using Regression Networks)



Learning to Track at 100 FPS with Deep Regression Networks, [Held, 2016]

Video representation learning

ImageNet для видео



Video representation learning

2011

2012

2013

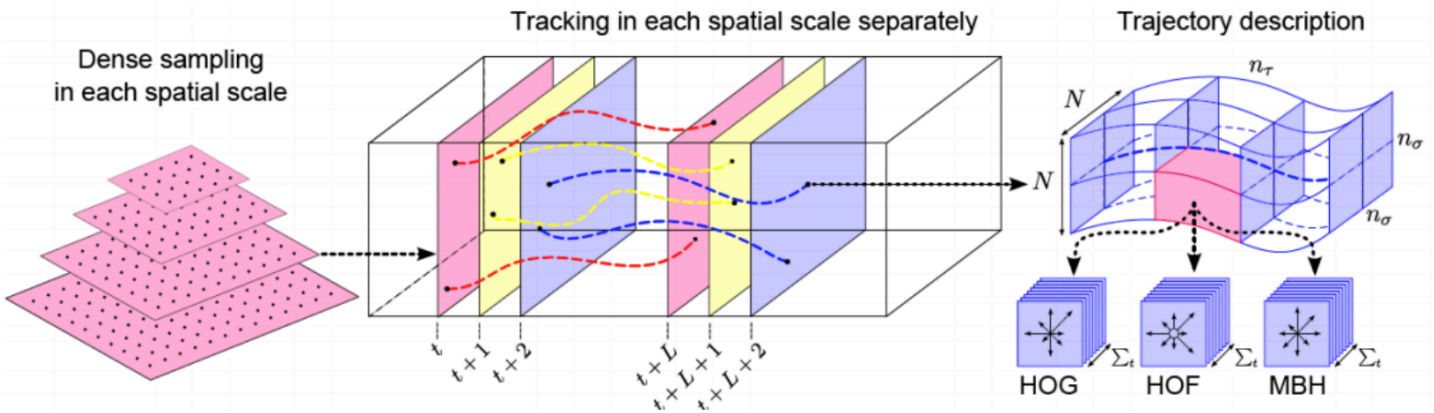
2014

2015

2016

Hand-crafted feature

Action recognition by dense trajectories. [Wang, CVPR'11]



- Чувствителен к движениям камеры и изменениям освещения
- Не содержит высокоуровневой семантической информации
- Долго вычисляется: не пригоден для real-time

Video representation learning

2011

2012

2013

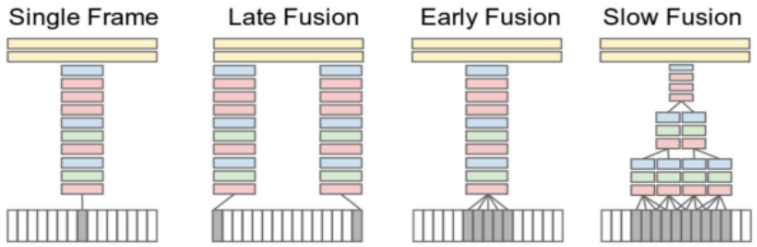
2014

2015

2016

2D Convolutional Neural Network

Large-scale Video Classification with Convolutional Neural Networks. [Karpathy, CVPR'14]



Two-Stream Convolutional Networks for Action Recognition in Videos. [Simonyan, NIPS'14]

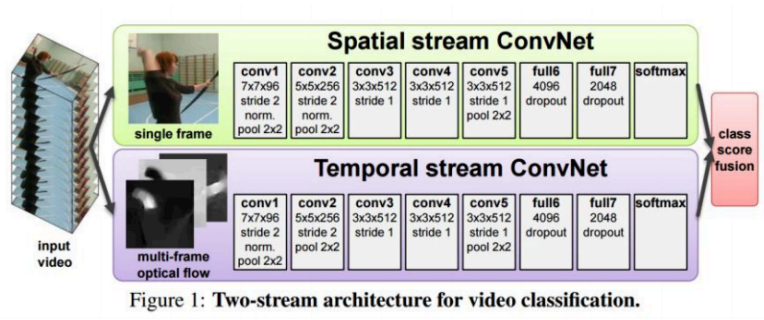
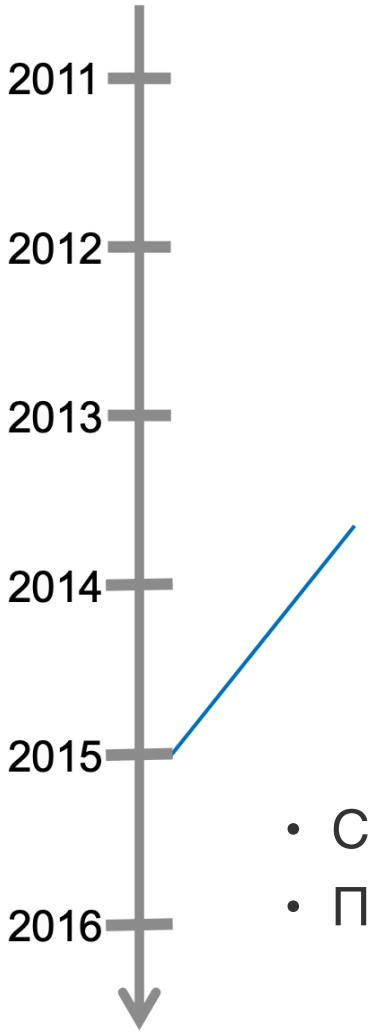


Figure 1: **Two-stream architecture for video classification.**

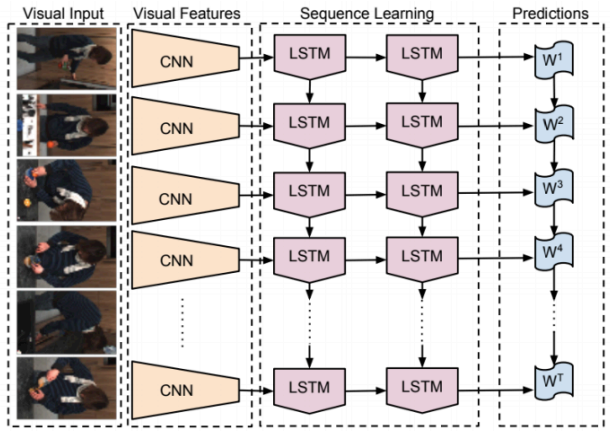
- Два потока: фреймы + движение
- 2D CNN для фреймов предобучена на ImageNet
- 2D CNN для движения обучается с нуля

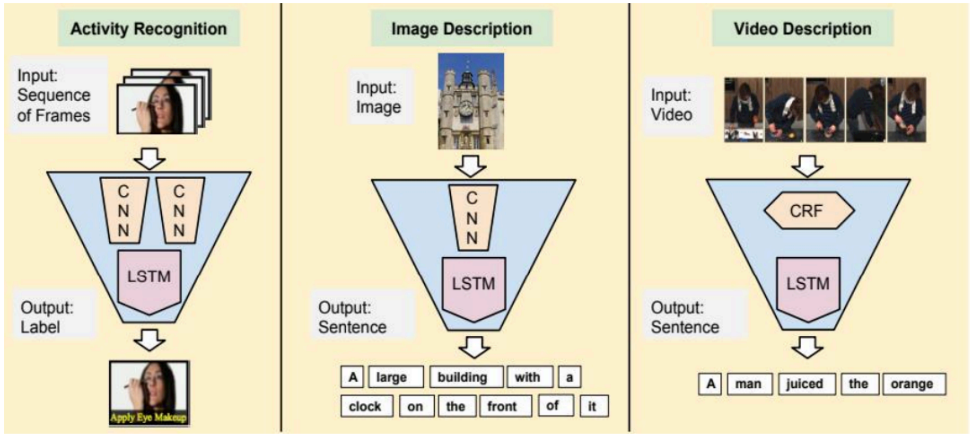
Video representation learning



2D CNN + LSTM (LRCN)

Long-term Recurrent Convolutional Networks for Visual Recognition and Description [Donahue, CVPR'15]

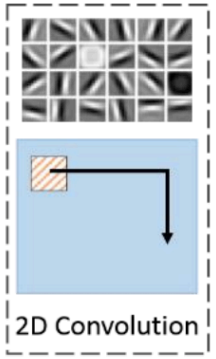




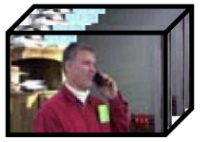
- Смесь CNN и RNN
- Применяется для распознавания действий и описания видео

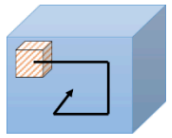
Video representation learning: Conv 3D

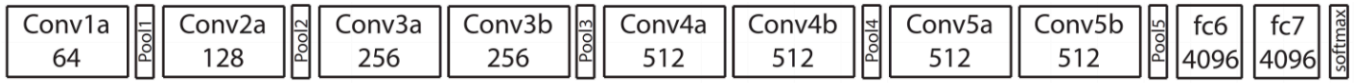
ResNet:
[MSRA, CVPR'16]



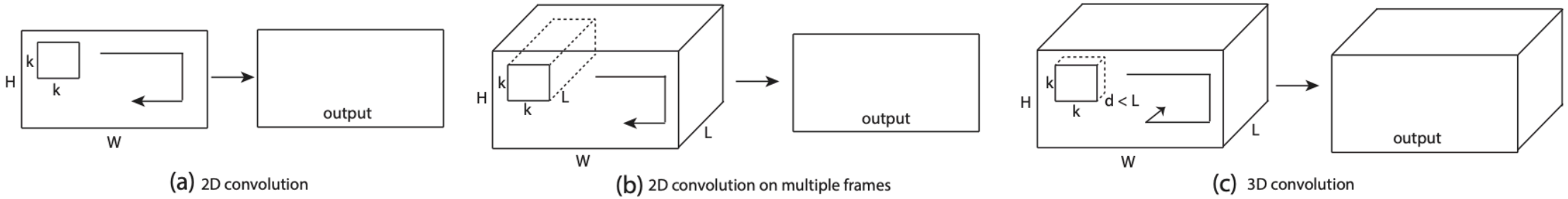
3D CNN:
[FAIR & NYU, ICCV'15]


video


3D ConvNet



Video representation learning: Conv 3D



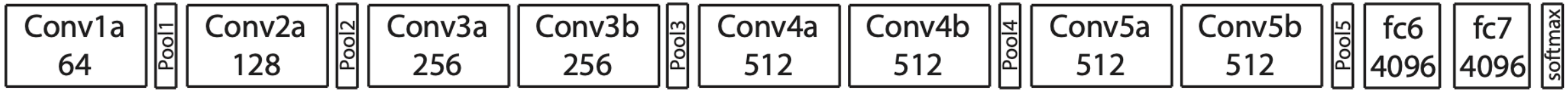
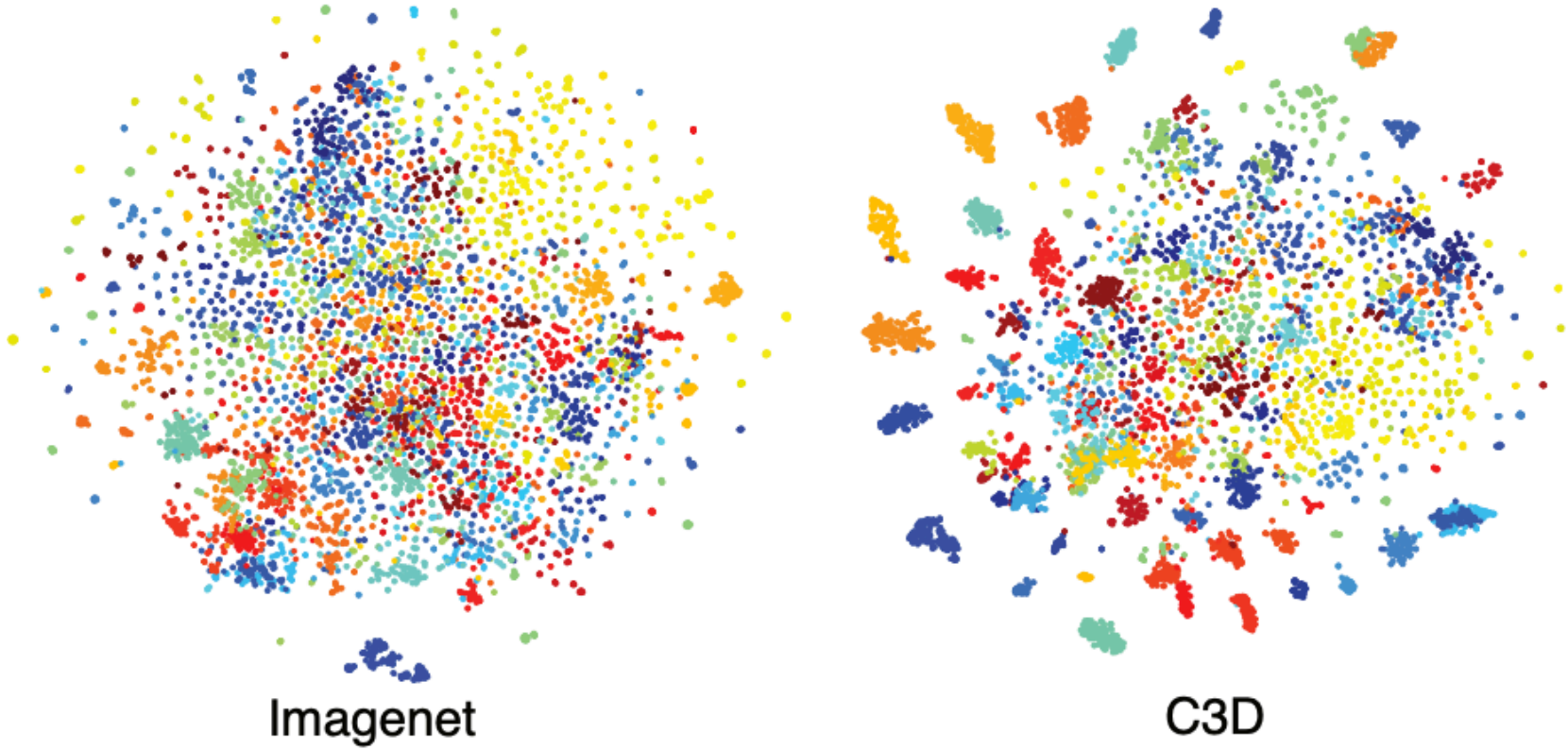
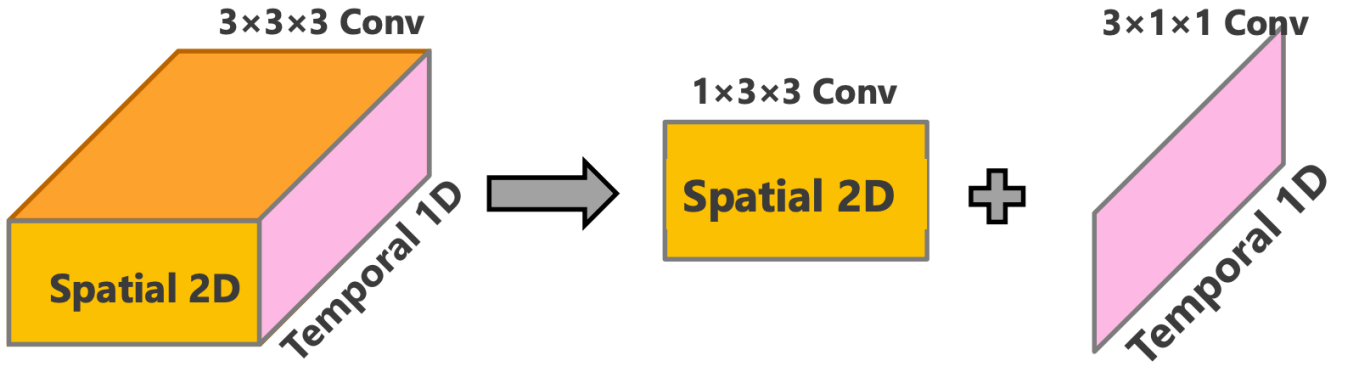


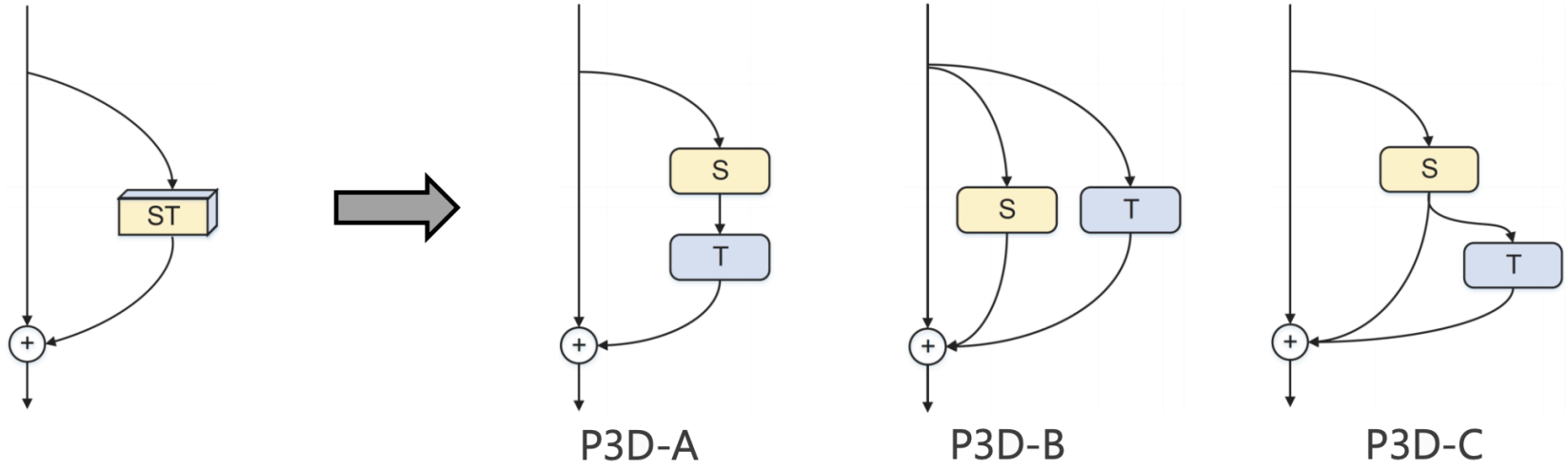
Figure 3. **C3D architecture**. C3D net has 8 convolution, 5 max-pooling, and 2 fully connected layers, followed by a softmax output layer. All 3D convolution kernels are $3 \times 3 \times 3$ with stride 1 in both spatial and temporal dimensions. Number of filters are denoted in each box. The 3D pooling layers are denoted from `pool1` to `pool5`. All pooling kernels are $2 \times 2 \times 2$, except for `pool1` is $1 \times 2 \times 2$. Each fully connected layer has 4096 output units.

Video representation learning: Conv 3D

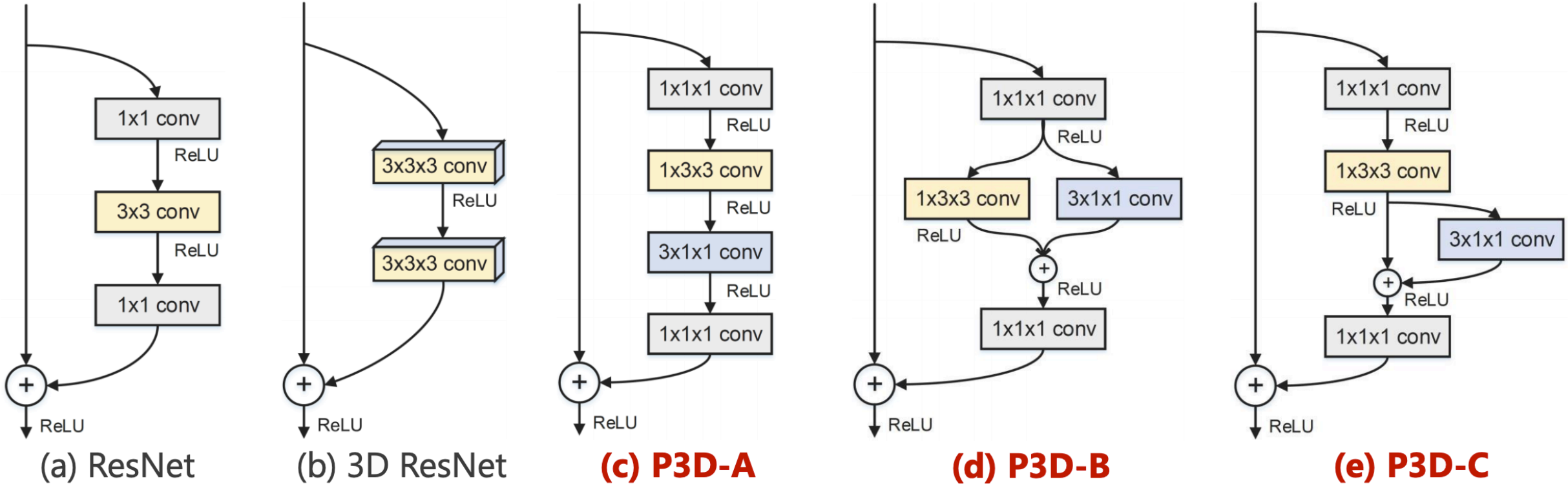


Video representation learning: Pseudo 3D ResNet



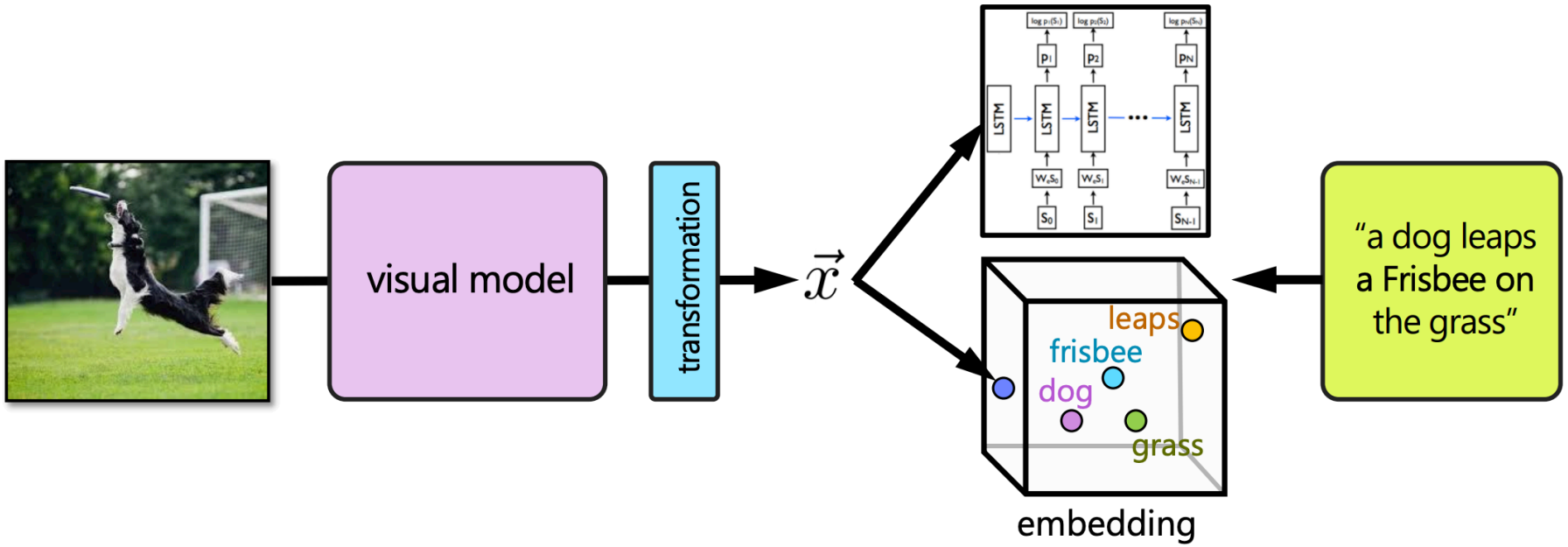


Video representation learning: Pseudo 3D ResNet



Video captioning

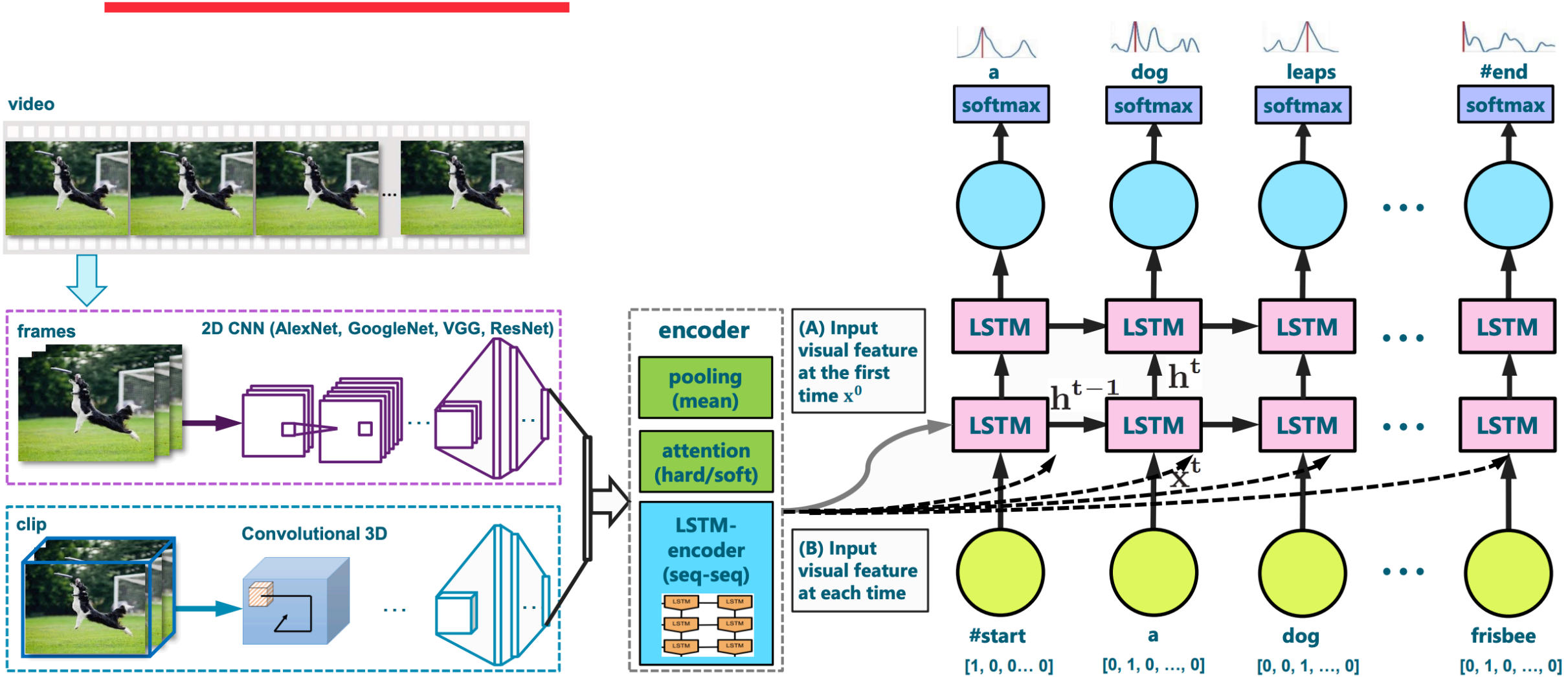
Video captioning: idea



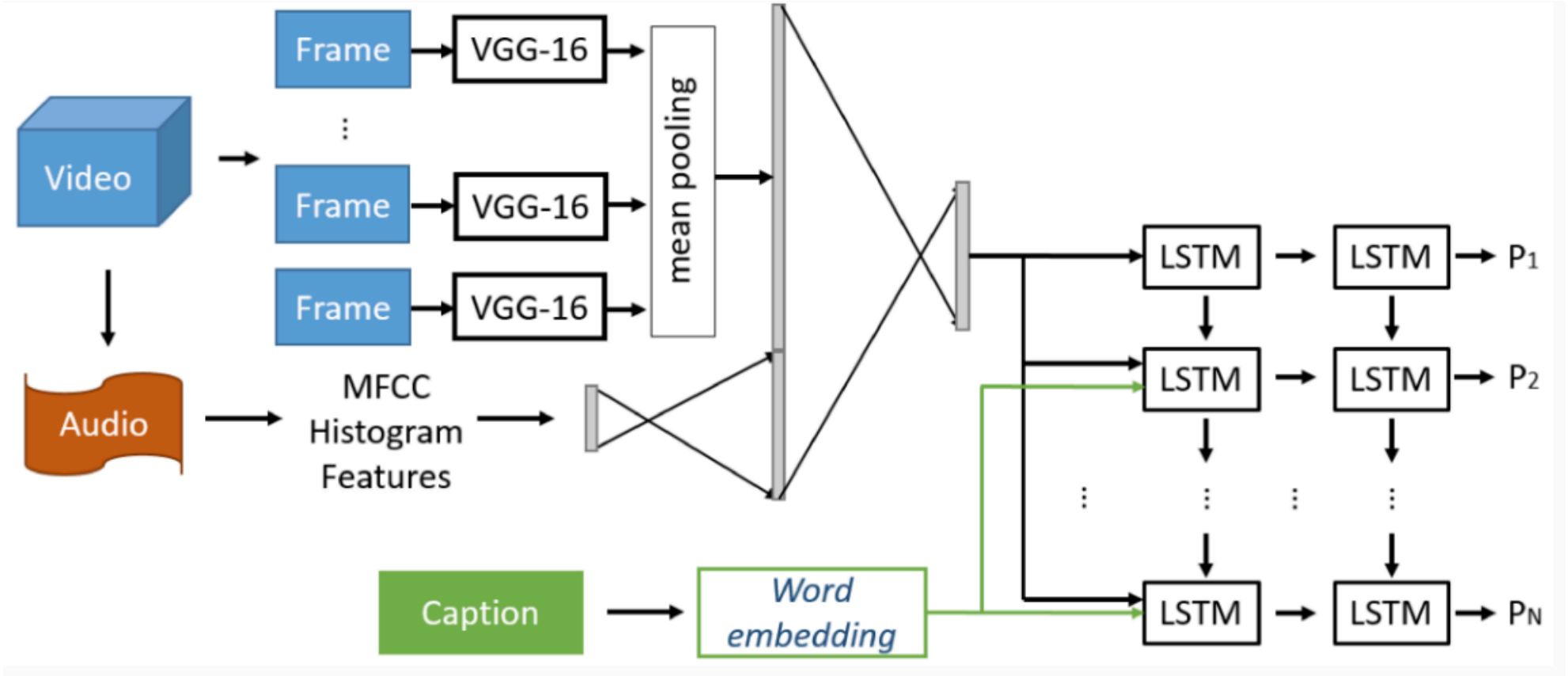
- Transforming an image/clip to a vector in visual space
  - CRF, CNN, Semantic Vector, CNN+Attention
- Transforming description to a vector in semantic space
  - Collection of words (BoW), sequence of words (RNN)
- Creating an embedding space
  - Language template (FGM, ME), RNNs (Encoder-Decoder), LSTM

- Methodologies
  - Search-based
  - Language template-based
  - Sequence learning-based
    - Generation: learning-decoder
    - Translation: encoder-decoder

Video captioning

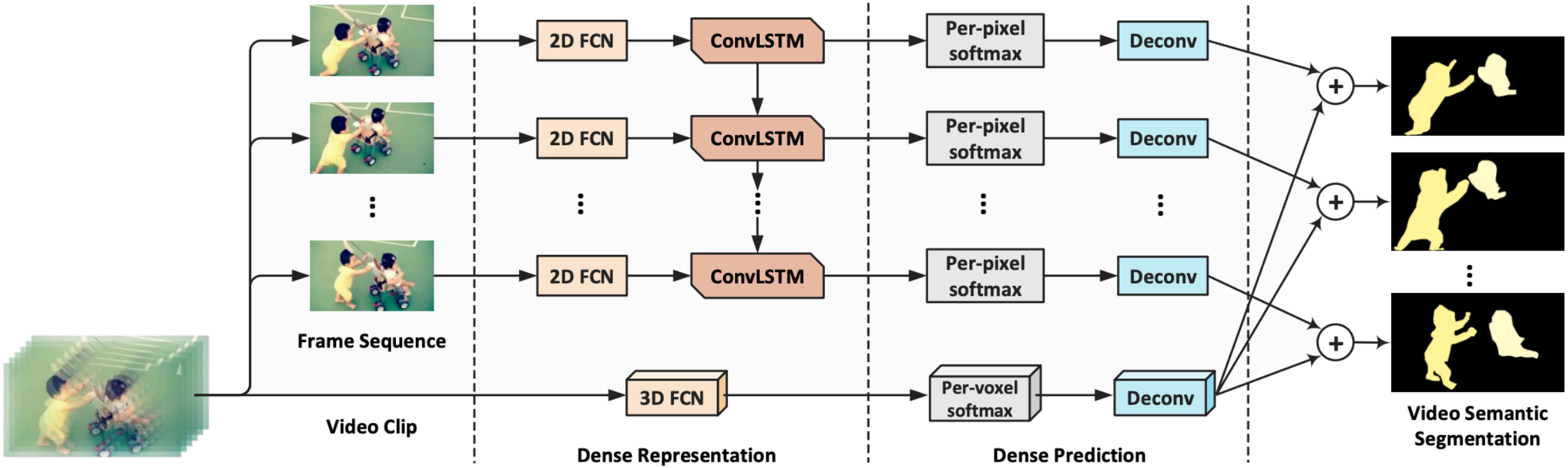


Video captioning



Video segmentation

Video segmentation



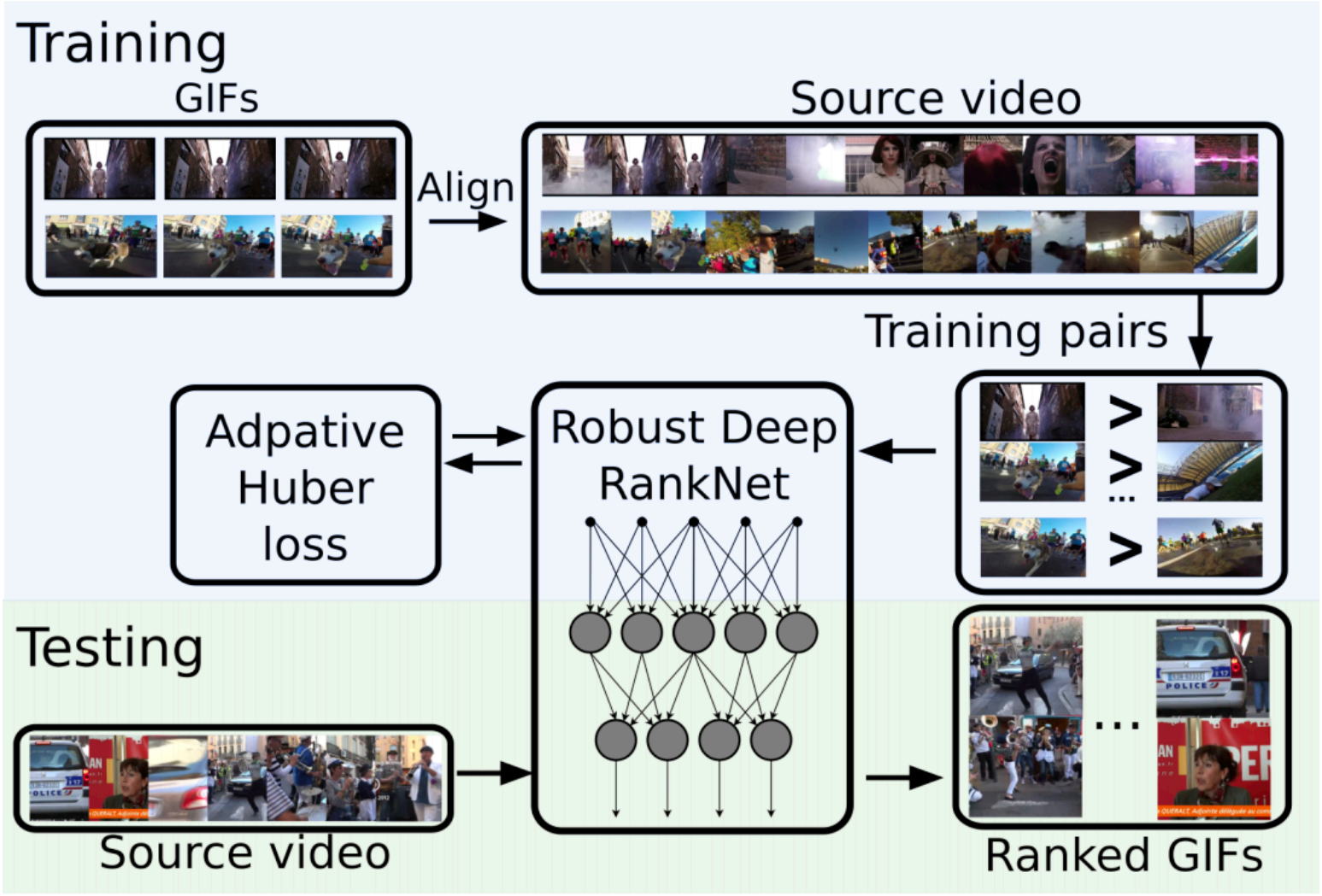
Highlights detection

Video highlights

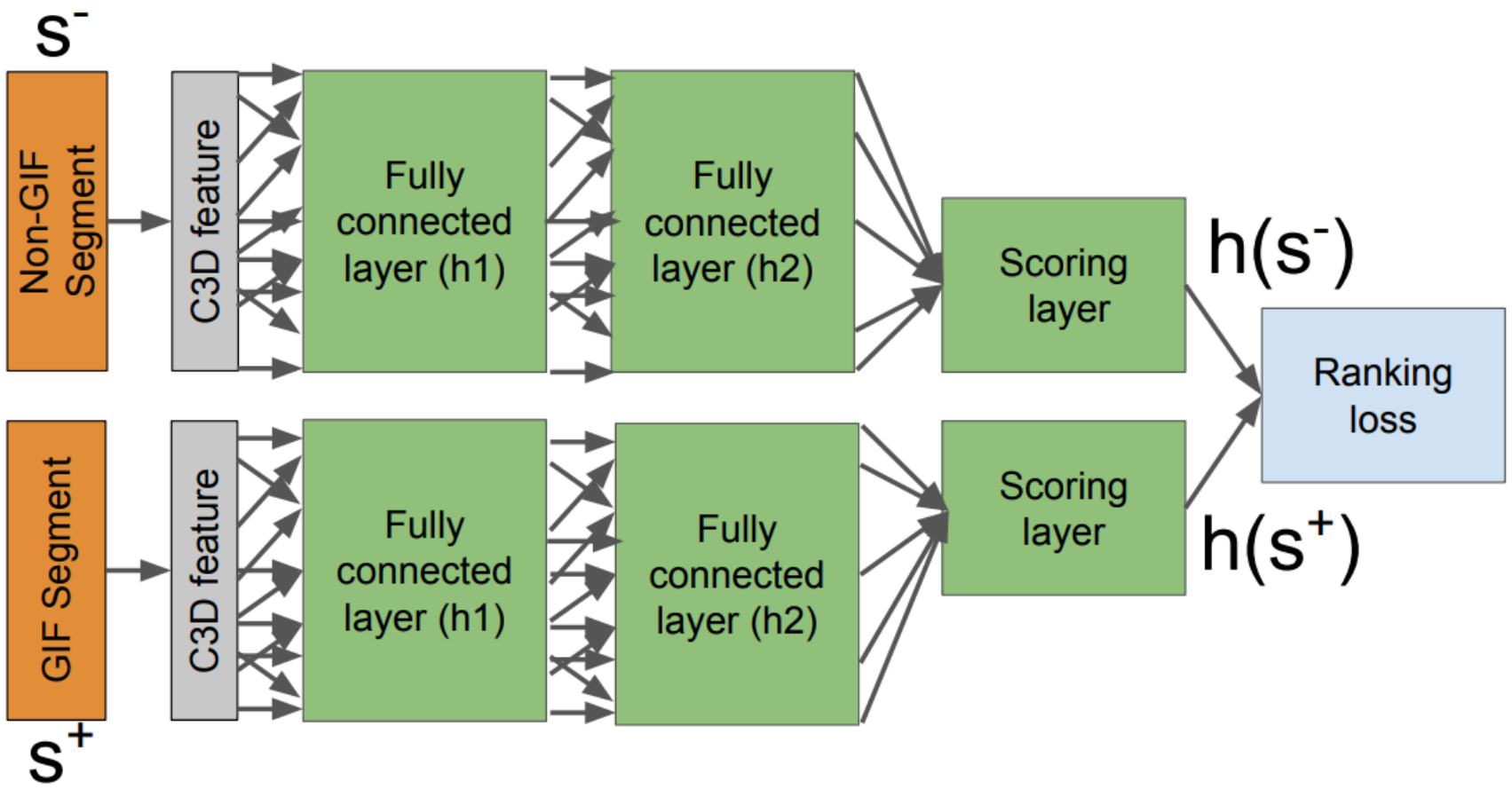
- Хайлайт — это важная, интересная часть видео
- Может использоваться для выделения основной информации о сюжете видео
- Разделим видео на сцены (segments) и будем ранжировать их (чем выше значение ранга, тем выше вероятность попадания сцены в хайлайт)
- Обучаемся на датасете Video2GIF
  - 120K видео из 80K видео

Video2GIF: Automatic Generation of Animated GIFs from Video, [Gygli, 2016]

Video highlights detection pipeline



Video highlights detection net



Loss function

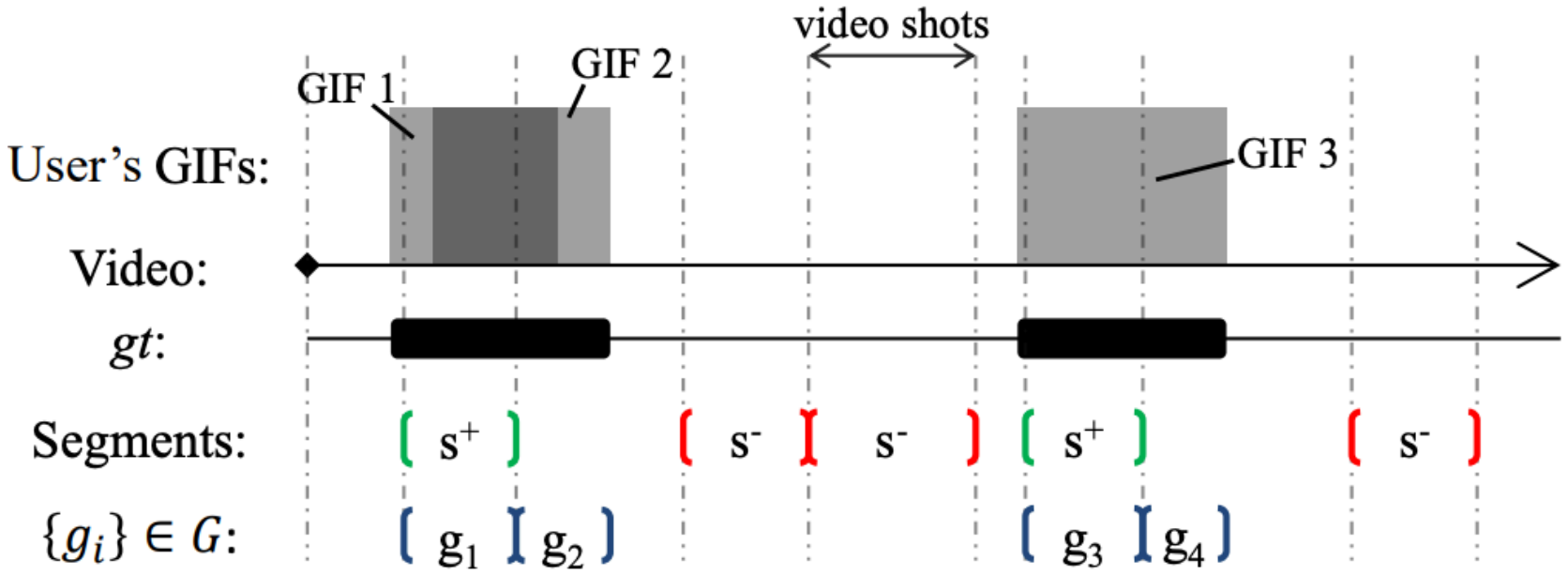
$$h(s^+) > h(s^-), \quad \forall \left(s^+, s^-\right) \in S.$$

$$l_p(s^+, s^-) = \max\left(0, 1 - h(s^+) + h(s^-)\right)^p$$

$$l_{\text{Huber}}(s^+, s^-) = \begin{cases} \frac{1}{2} l_2(s^+, s^-), & \text{if } u \leq \delta \\ \delta l_1(s^+, s^-) - \frac{1}{2}\delta^2, & \text{otherwise} \end{cases}$$

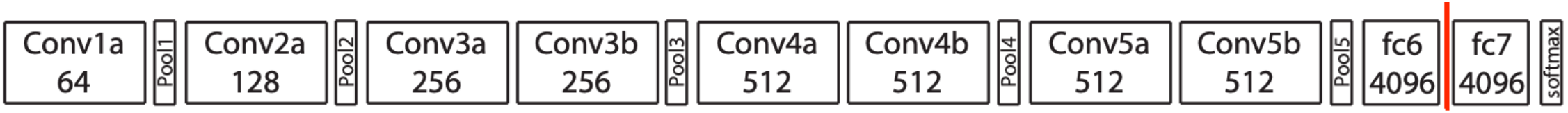
$$L(\mathcal{D}, \mathbf{W}) = \sum_{S_i \in \mathcal{D}} \sum_{(s^+, s^-) \in S_i} l_{\text{Huber}}(s^+, s^-) + \lambda ||\mathbf{W}||_F^2$$

Positive / negative segments

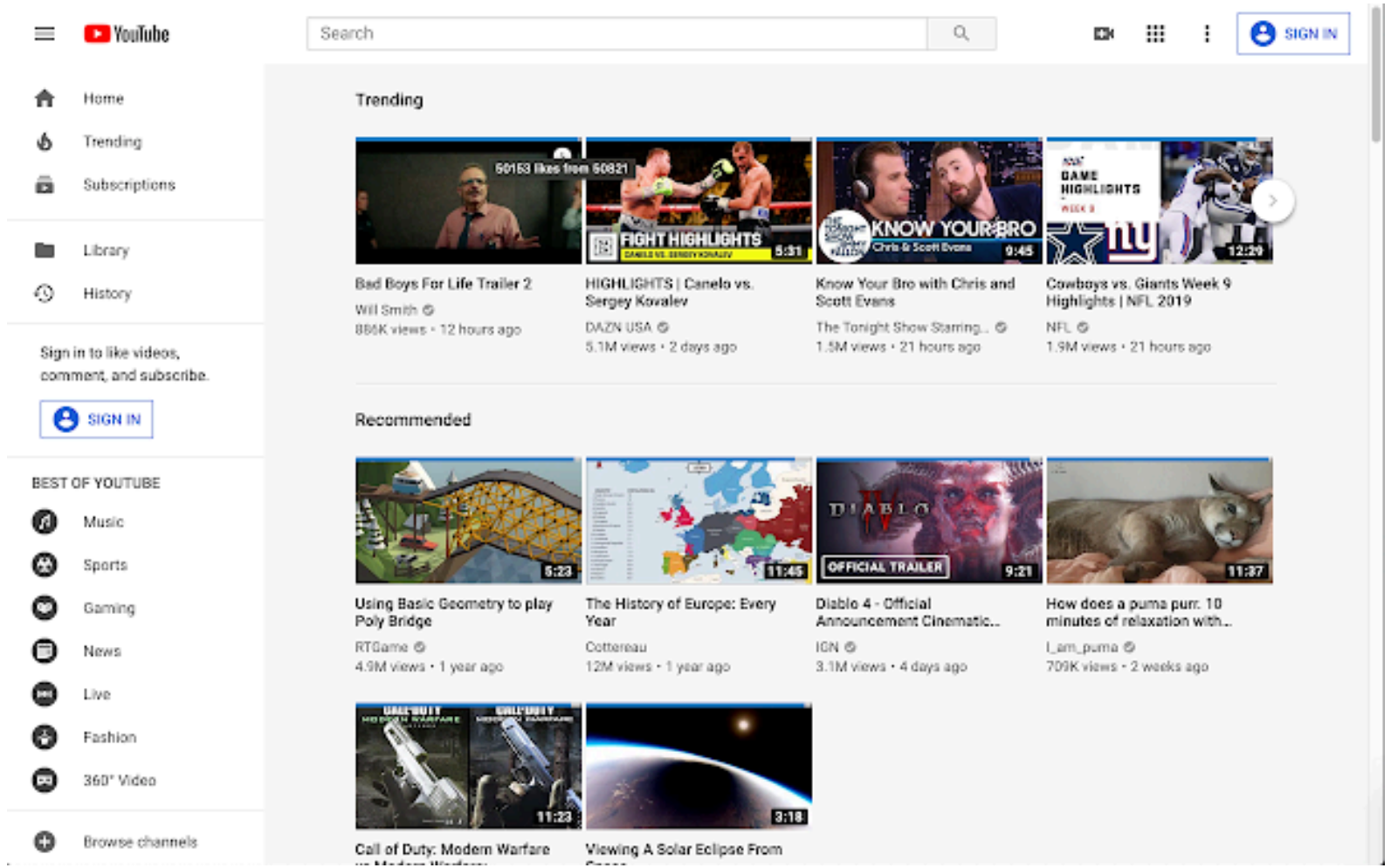


Video segments embeddings

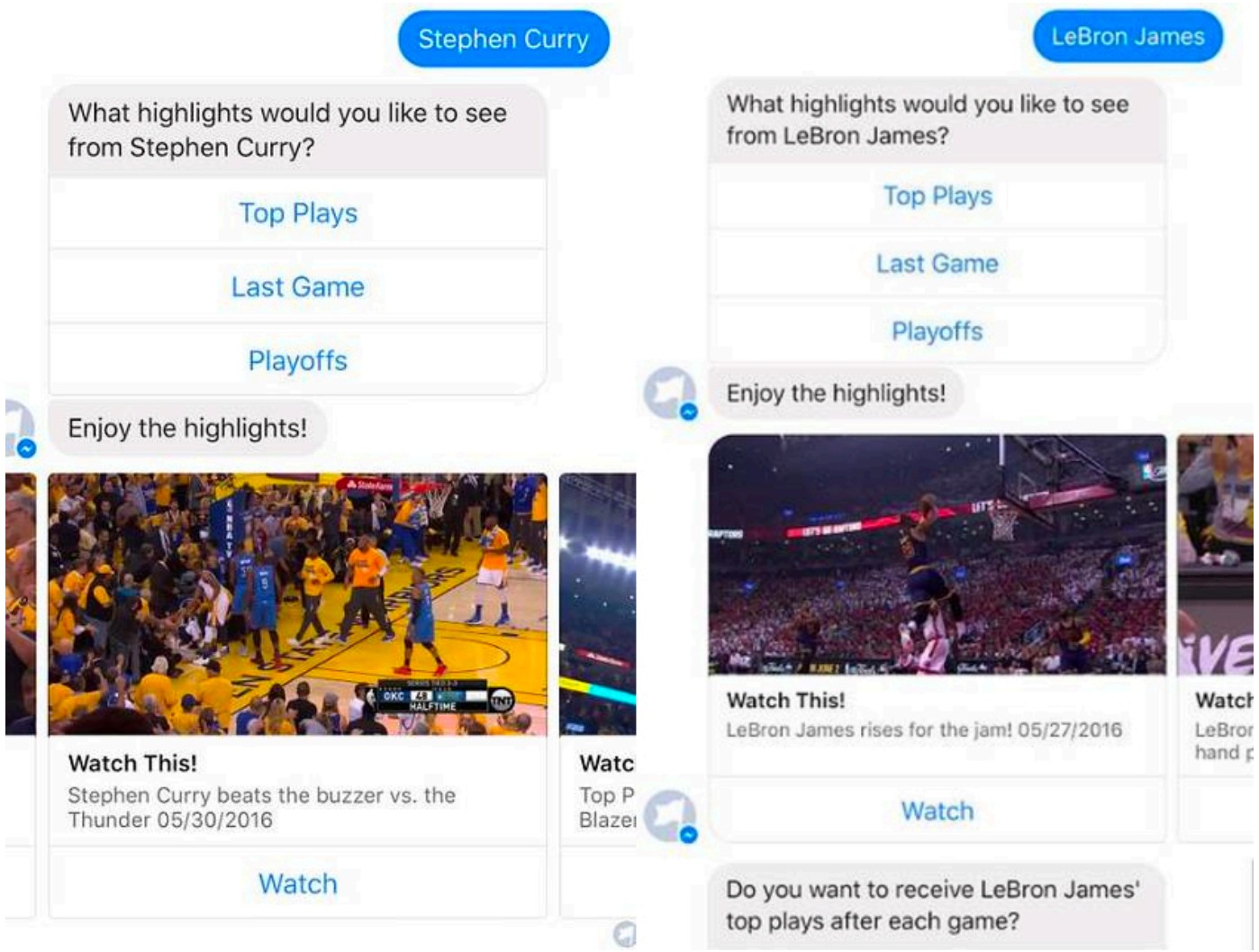
- Используем Conv 3D
- Sports-1M Dataset
  - 1 133 158 видео, 487 классов



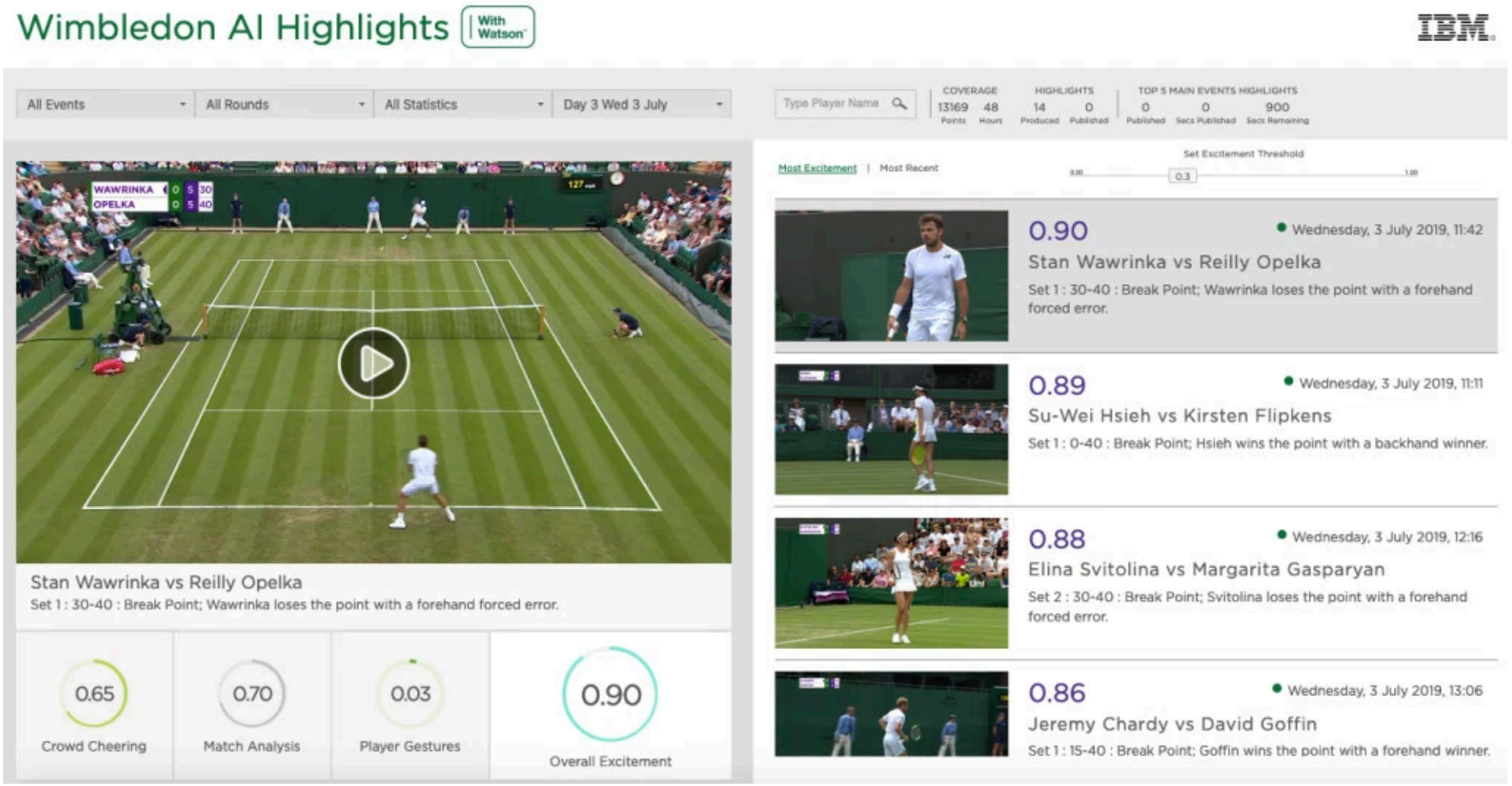
YouTube preview



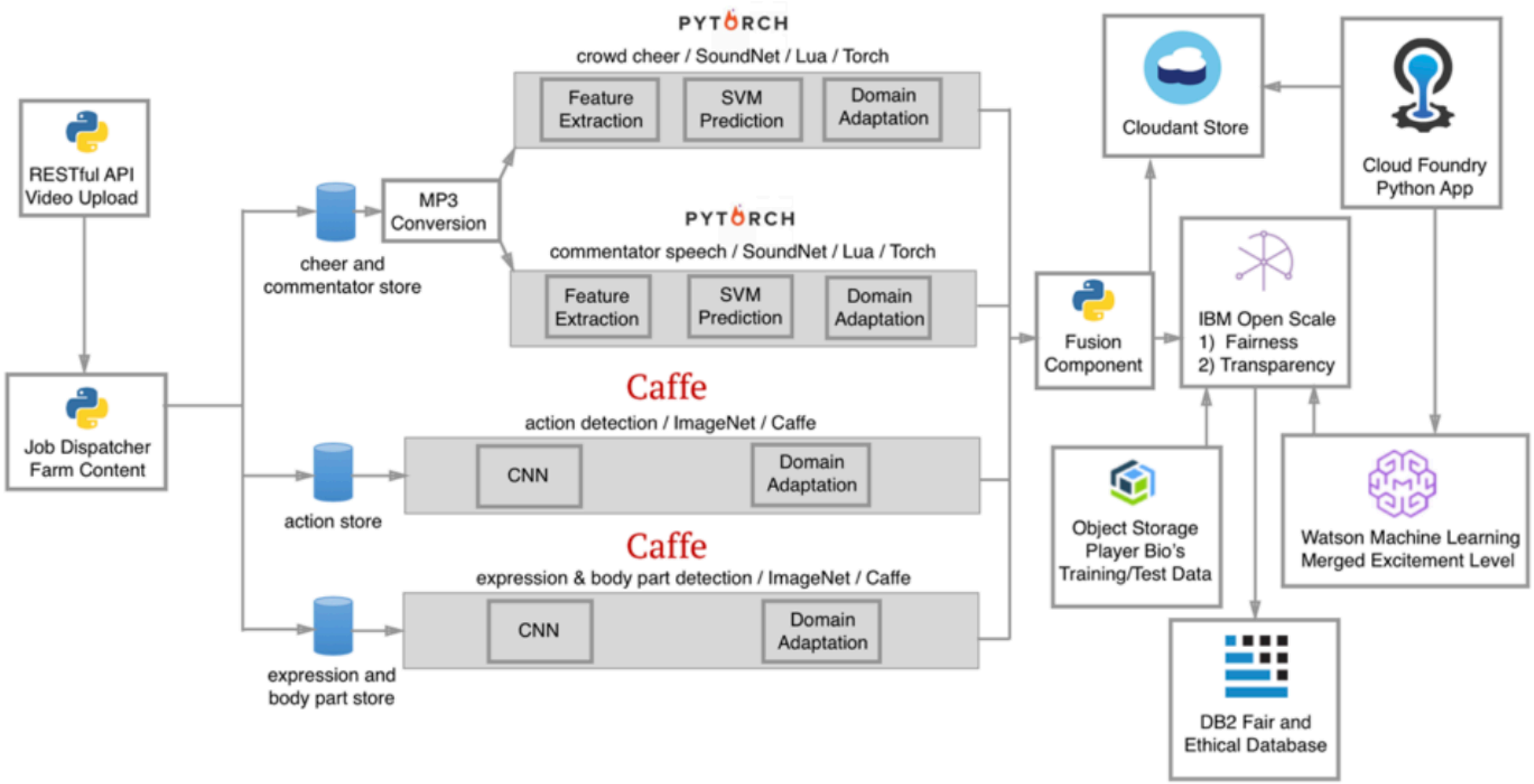
NBA Highlights



IBM Wimbledon Highlights



IBM Wimbledon Highlights



Заключение

- Анализ видео на порядок сложнее анализа изображений
  - Больше данных
  - Дольше время обработки
- Важно учитывать порядок фреймов по времени
- Есть звук (отдельная тема)
- Используется смесь из нескольких моделей
  - Conv 3D
  - RNN