MxNet Gluon

Basics, Computer Vision, NLP (and even more NLP)

Part I (Basics)

Leonard Lausen
Haibin Lin
Alex Smola

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Outline

8:30-9:15	Installation and Basics (NDArray, AutoGrad, Libraries)
9:15-9:30	Neural Networks 101 (MLP, ConvNet, LSTM, Loss, SGD) - Part I
9:30-10:00	Break
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16:00-16:15	Sentiment analysis
16:15-17:00	Transformer Models & machine translation
17:00-17:30	Questions

What can deep learning do?

Classify Images

http://www.image-net.org/

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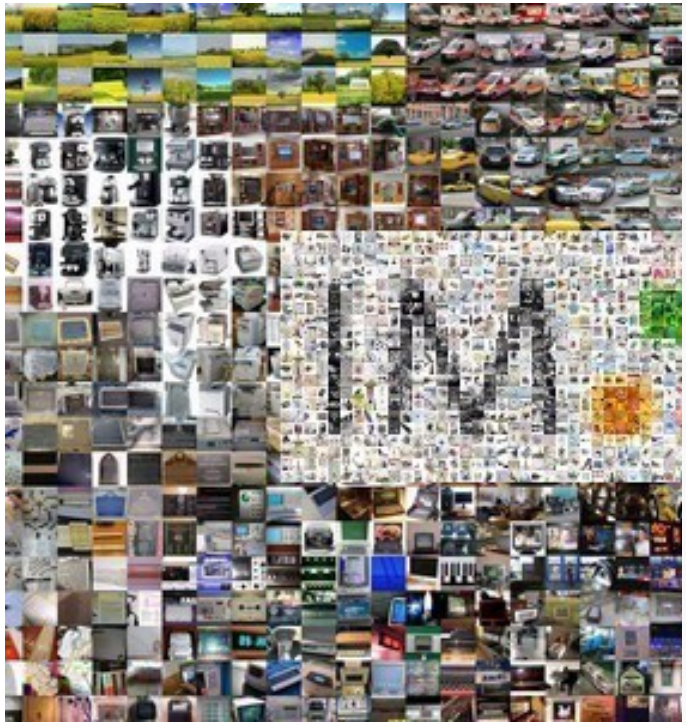
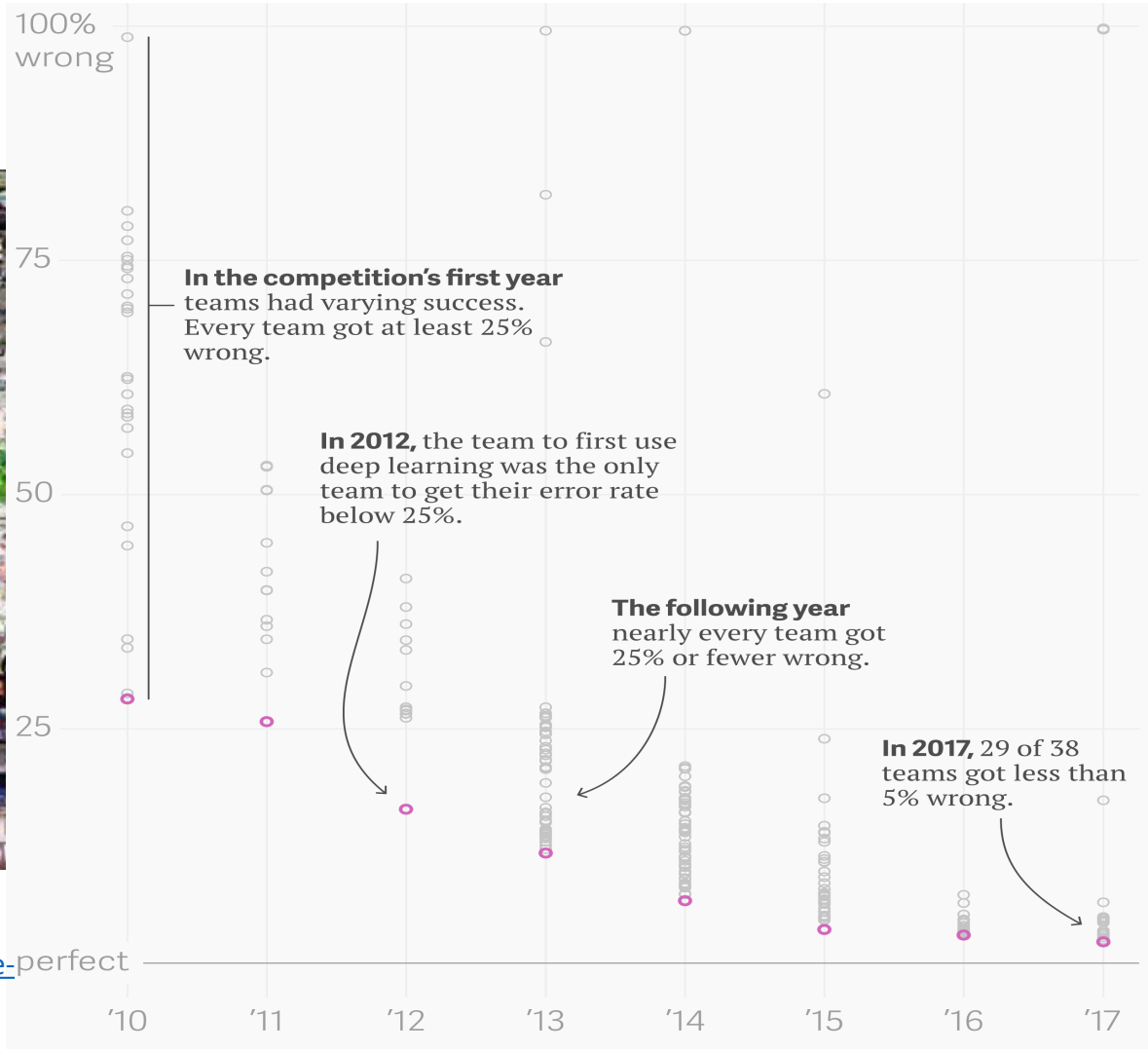
Classify Images





Yanofsky, Quartz
https://qz.com/1034972/the-data-that-changed-the-direction-of-ai-research-and-possibly-the-world/

Detect and Segment Objects

https://github.com/matterport/Mask_RCNN

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Style transfer

https://github.com/zhanghang1989/MXNet-Gluon-Style-Transfer/

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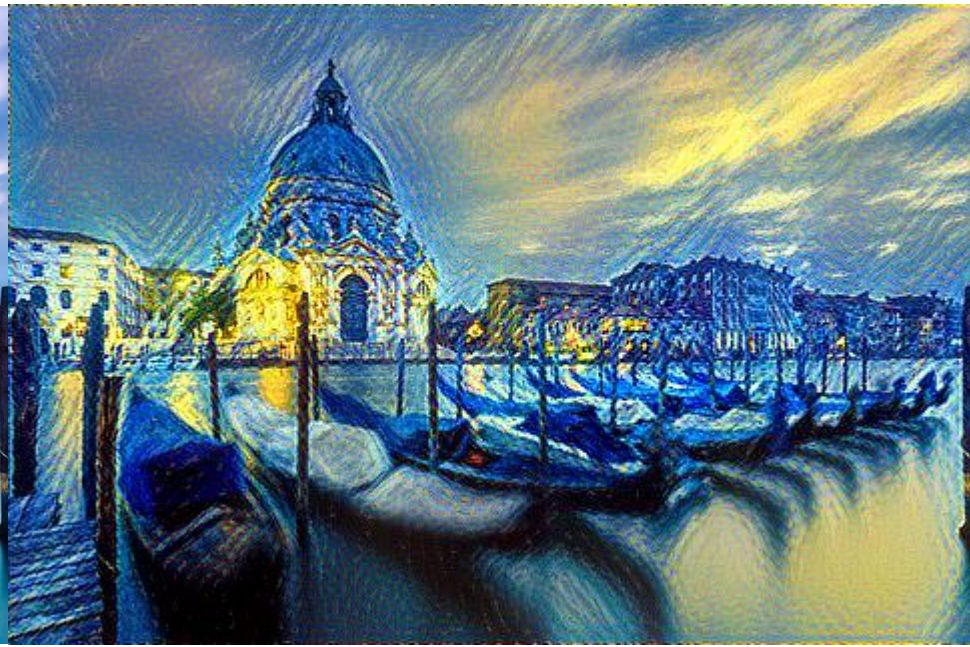

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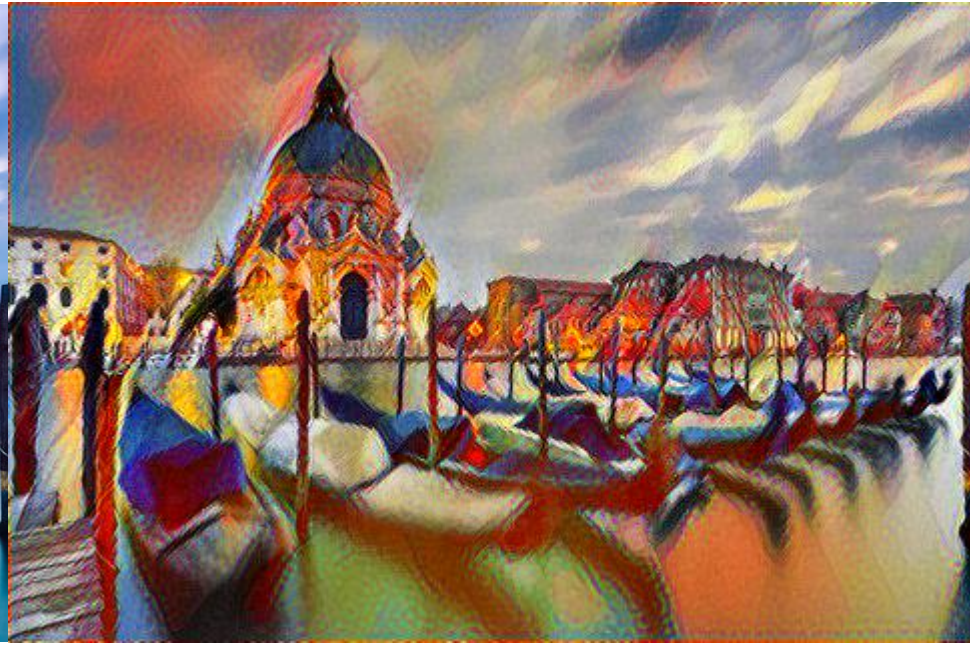

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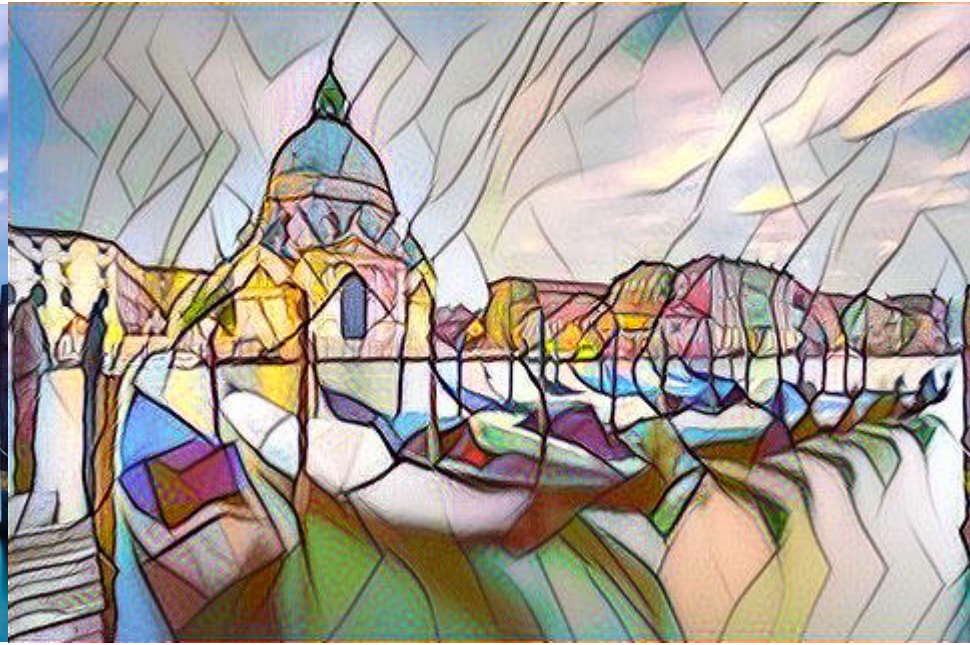

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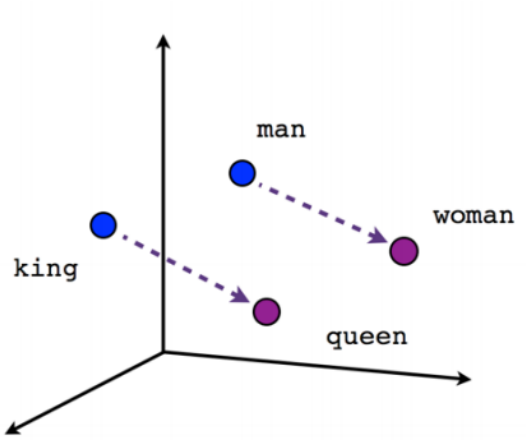
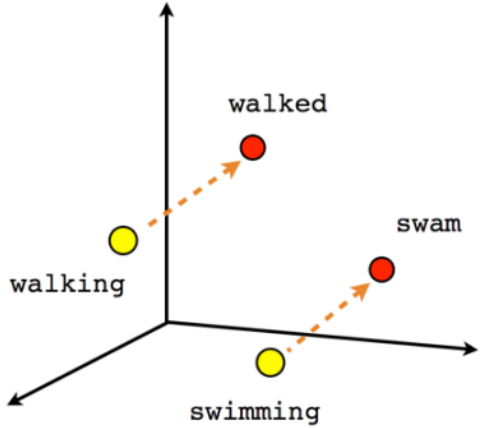
Synthesize Faces

Karras et al, ICLR 2018

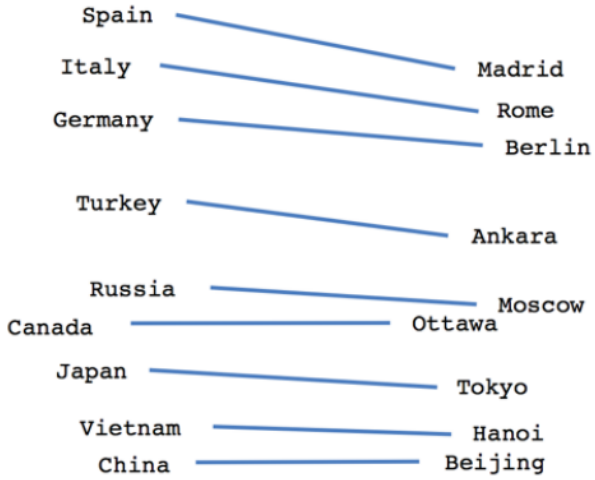
Analogies



Male-Female



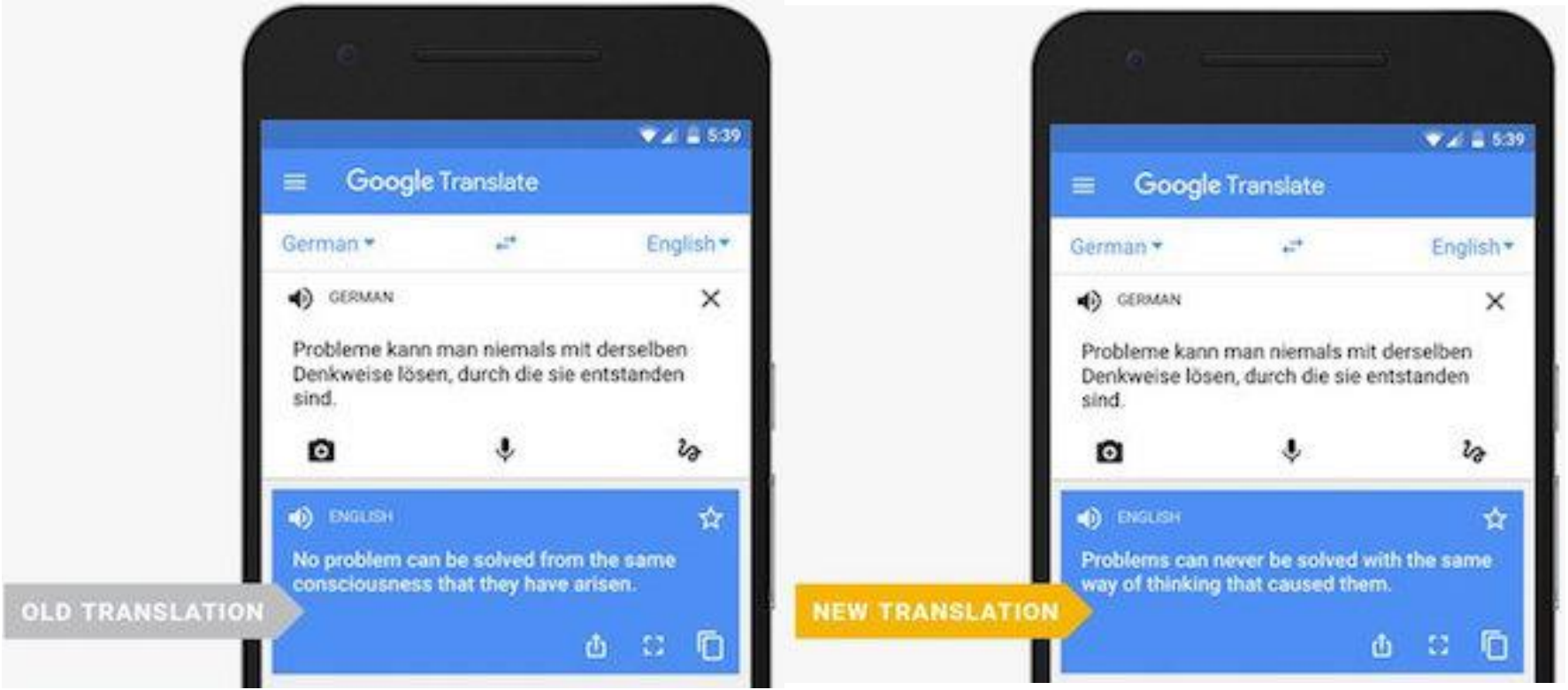
Verb tense



Country-Capital

https://www.tensorflow.org/tutorials/word2vec

Machine Translation



https://www.pcmag.com/news/349610/google-expands-neural-networks-for-language-translation

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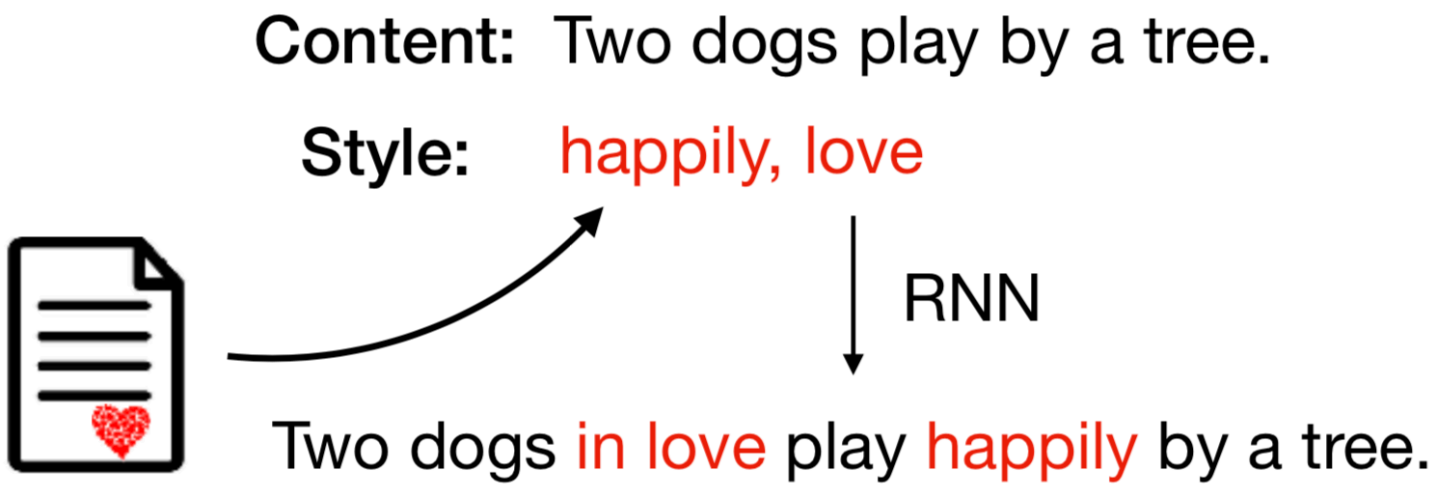
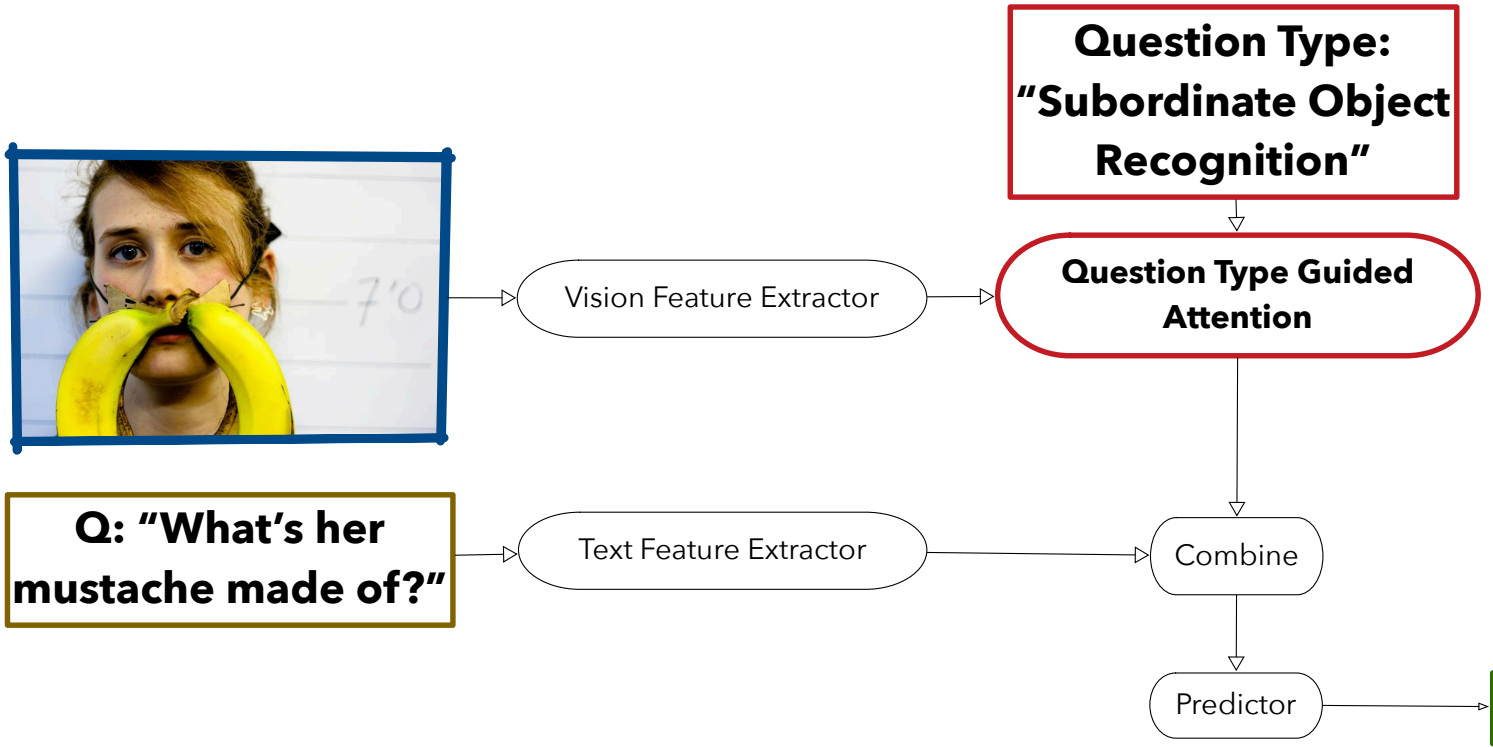
Text synthesis



Li et al, NACCL, 2018

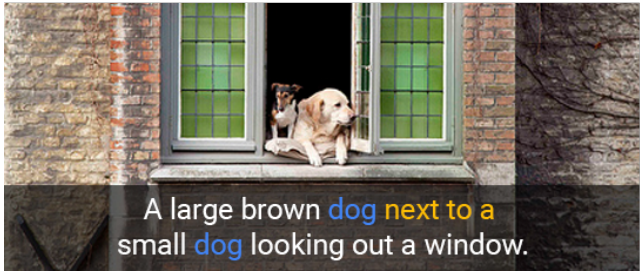
Question answering



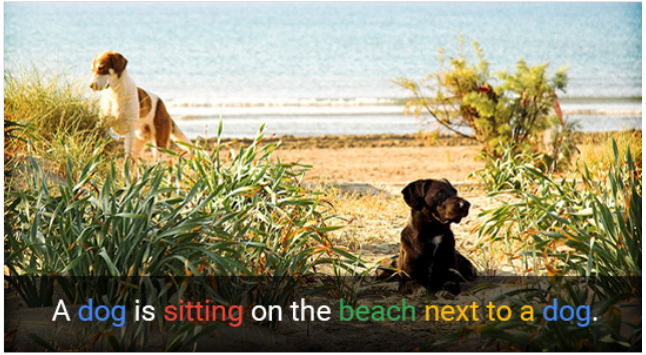
Shi et al, 2018, Arxiv

Image captioning

Human captions from the training set



Automatically captioned



Shallue et al, 2016
https://ai.googleblog.com/2016/09/show-and-tell-image-captioning-open.html

OK, I’m sold … I want this! Now!

Programming for deep learning used to be…

```
void computeLogregSoftmaxGrad(NVMatrix& labels, NVMatrix& probs, NVMatrix& target, bool add, float coeff) {
    int numCases = probs.getLeadingDim();
    int numOut = probs.getFollowingDim();
    assert(labels.getNumElements() == numCases);
    assert(probs.isContiguous());
    assert(target.isContiguous());
    assert(labels.isContiguous());
    assert(probs.isTrans());

    dim3 threads(LOGREG_GRAD_THREADS_X, LOGREG_GRAD_THREADS_Y);
    dim3 blocks(DIVUP(numCases, LOGREG_GRAD_THREADS_X), DIVUP(numOut, LOGREG_GRAD_THREADS_Y));
    if (!add) {
        target.resize(probs);
        kLogregSoftmaxGrad<false><<<blocks, threads>>>(probs.getDevData(), labels.getDevData(), target.getDevData(),
                                                       numCases, numOut, coeff);
    } else {
        kLogregSoftmaxGrad<true><<<blocks, threads>>>(probs.getDevData(), labels.getDevData(), target.getDevData(),
                                                      numCases, numOut, coeff);
    }

    getLastCudaError("computeLogregSoftmaxGrad: Kernel execution failed");
}
```

Krizhevsky et al, code from cuda-convnet (AlexNet)

Programming for deep learning today

```
loss_function = gluon.loss.SoftmaxCrossEntropyLoss()
loss = loss_function(output)
loss.backward()
```

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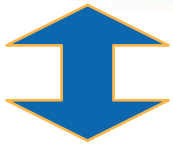
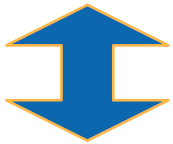
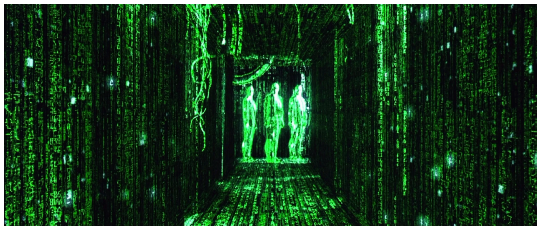
Programming for deep learning today


```
output = model(data)
```

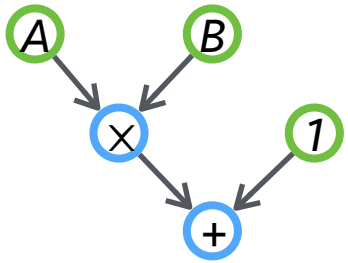






[crazy GPU stuff]

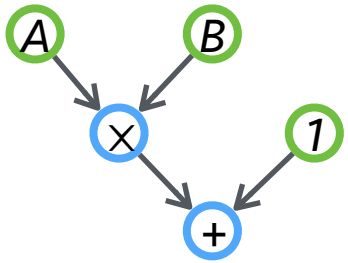
Declarative (Symbolic) Programs




```
A = Variable('A')
B = Variable('B')
C = B * A
D = C + 1
f = compile(D)
d = f(A=np.ones(10),
      B=np.ones(10)*2)
```

- **Advantages**:
  - Opportunities for optimization
  - Easy to serialize models
  - More portable across languages
- **Disadvantages**:
  - Hard to debug
  - Unsuitable for dynamic graphs
  - Can’t use native code

Declarative (Symbolic) Programs

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```

C can share memory with *D*

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Imperative Programs


```
import numpy as np
a = np.ones(10)
b = np.ones(10) * 2
c = b * a
print c
d = c + 1
```

Easy to debug, easy to code

- **Advantages**
  - Straightforward and flexible
  - Use language natively (loops, control flow, debugging)
- **Disadvantages**
  - Hard to optimize (Fixed with JIT compiler!)

MXNet Gluon

Q: Why GLUON?

A:  + 

Laptop Setup

- Get today's notebooks
  `git clone https://github.com/szha/KDD18-Gluon`
- Set up Conda environment
  - `conda env update --prune mxnet/kdd18_gluon_nlp`
  - `conda activate kdd18_gluon_nlp`

Resources

- Deep Learning — the Straight Dope
  https://gluon.mxnet.io/
- A 60-minute Gluon Crash Course
  https://gluon-crash-course.mxnet.io/
- GluonCV
  http://gluon-cv.mxnet.io/
- GluonNLP
  https://gluon-nlp.mxnet.io/
- MXNet User Forum
  http://discuss.mxnet.io/
- MXNet Documentation
  https://mxnet.apache.org/

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NDArray and AutoGrad

Matrices and Vectors

- **A Simple ML algorithm**

```
initialize function f(x,w)
for (x,y) in data:
      l = loss(y, f(x,w))
      g = gradient(l)
      w = w - eta * g
```

- Need vectors to deal with w
- Need matrices to deal with chain rule for loss gradient
- Need high performance linear algebra

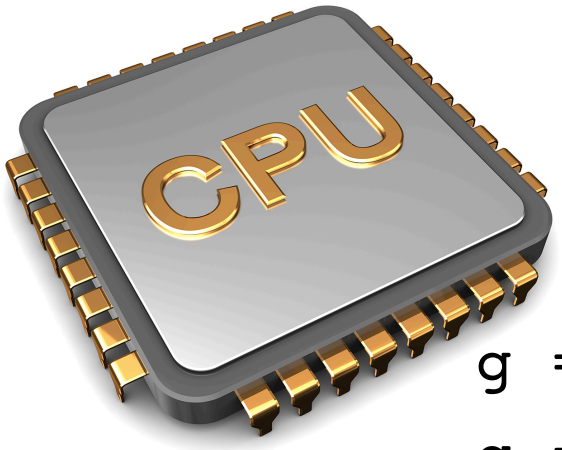
NDArray (Linear Algebra on GPUs in Python)

- **NumPy**
  - Limited to CPUs
  - No automatic differentiation
  - **Blocking (returns only once computation is performed)**
- **NDArray**
  - Multiple CPUs / GPUs via device context
  - Distributed systems in the cloud
  - **Nonblocking Python frontend (no GIL)**
  - **Lazy evaluation**

NDArray Device Contexts

```
context = mx.cpu()
```

```
context = mx.gpu(0)
context = mx.gpu(1)
```



```
g = copyto(c)
g = c.as_in_context(mx.gpu(0))
```

Automatic Differentiation

```
x = nd.array([[1, 2], [3, 4]])
x.attach_grad()
with ag.record():
    y = x * 2
    z = y * x
z.backward()
```

$$\partial_x \sum_i z[i](x) \textbf{ not } \partial_x z[i](x)$$

AutoGrad computes gradients without a declared compute graph