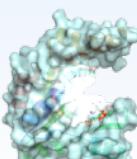


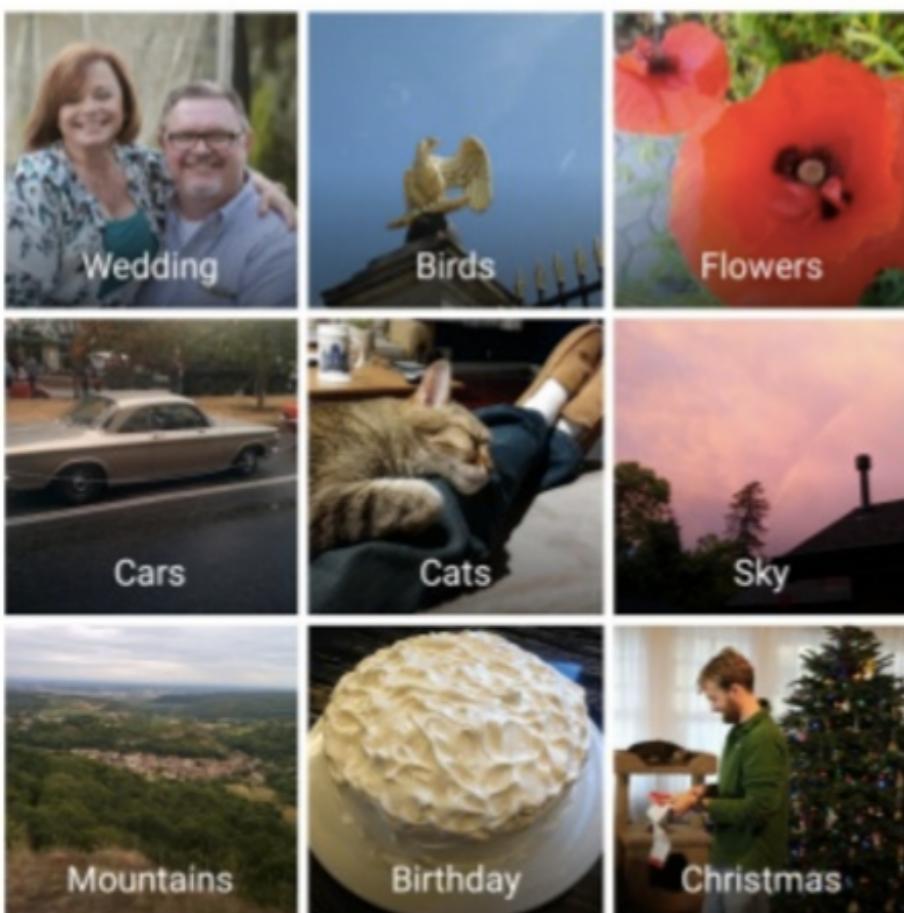
APPLICATIONS



Catalit LLC

APPLICATIONS

Things

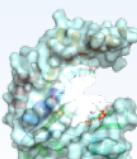


Google my photos of siamese cats X

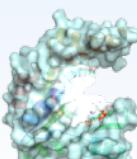
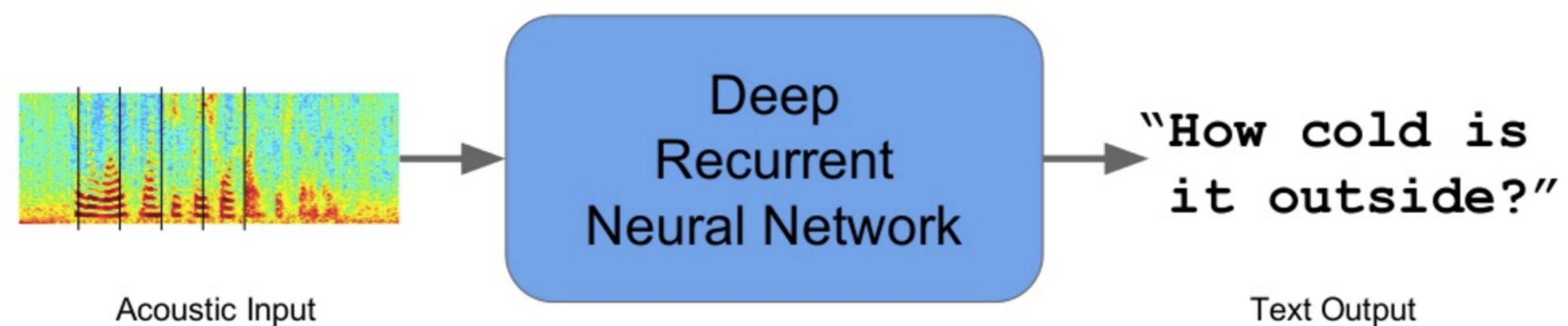
Web Images Shopping Videos More ▾

Your photos
Only you can see these results

The search results page shows a grid of 12 images of Siamese cats, which are the user's own photos from their Google Photos account.



APPLICATIONS



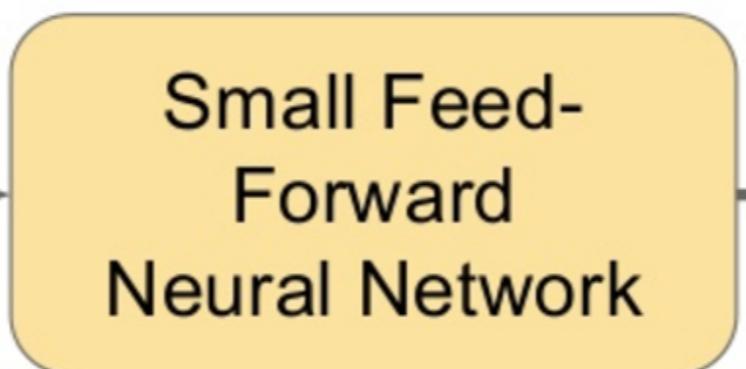
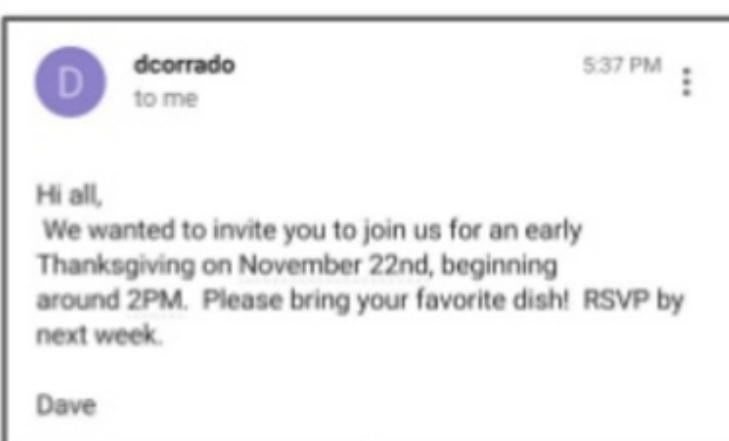
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APPLICATIONS

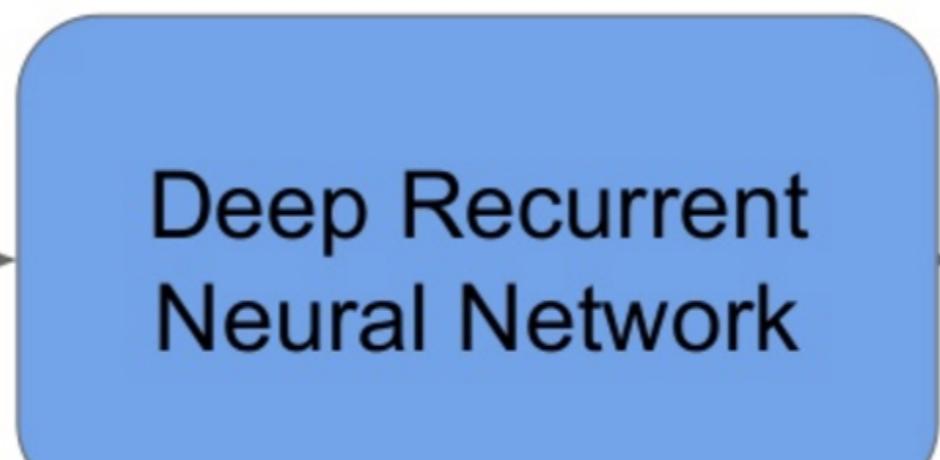
Smart Reply

Google Research Blog
- Nov 2015

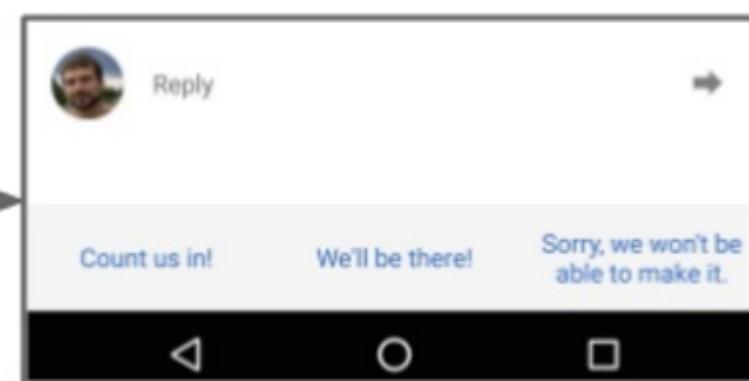
Incoming Email



Activate
Smart Reply?
yes/no



Generated Replies



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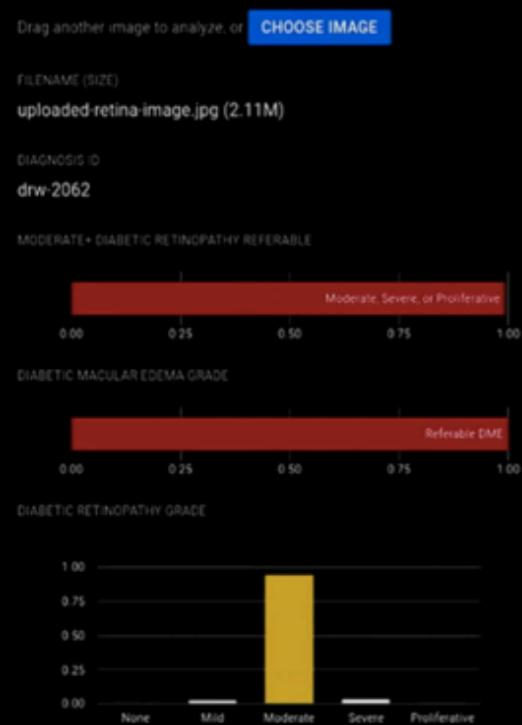
APPLICATIONS



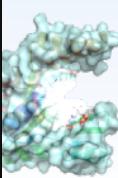
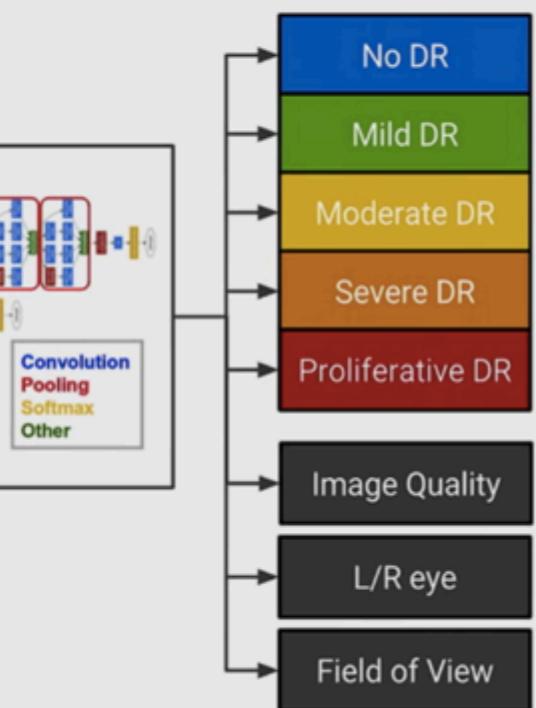
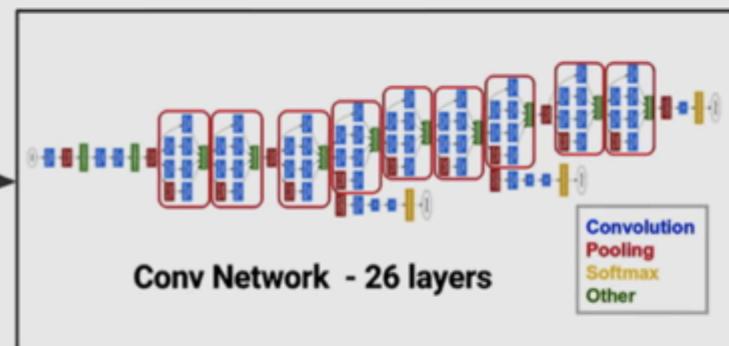
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APPLICATIONS

ARDA: Automated Retinal Disease Assessment



Adapt deep neural network to read fundus images



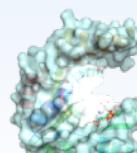
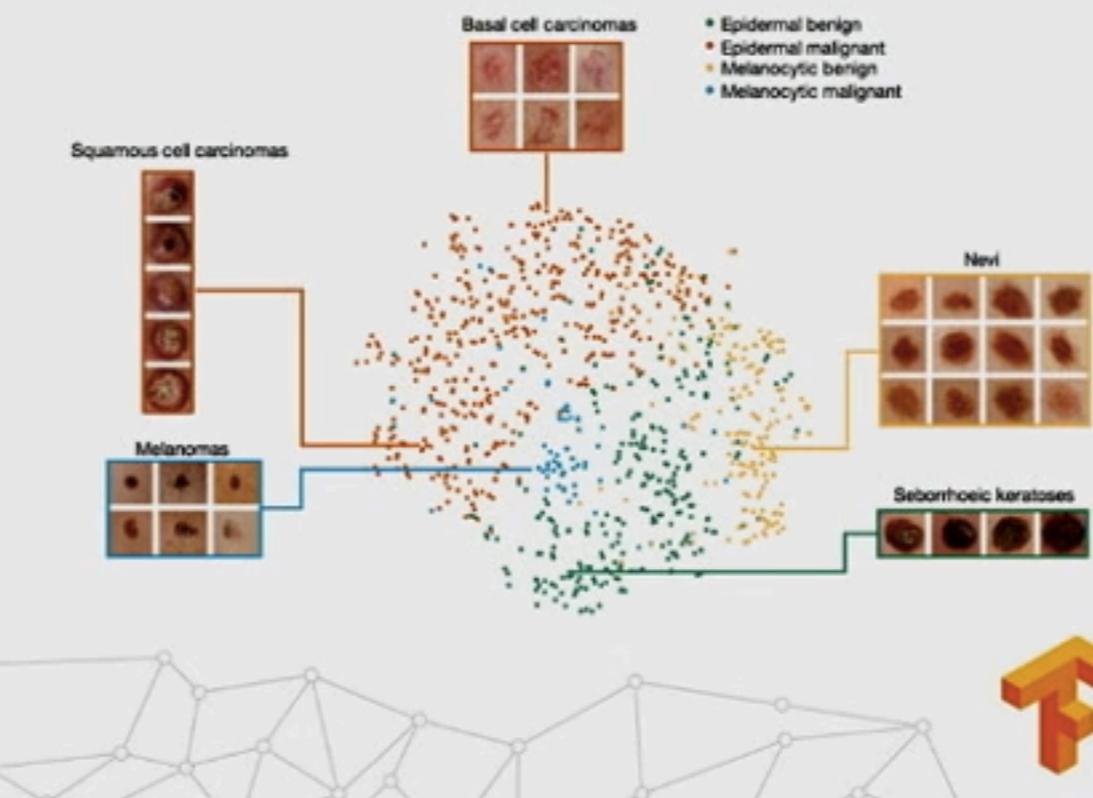
APPLICATIONS



LETTER

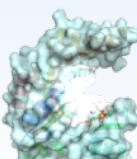
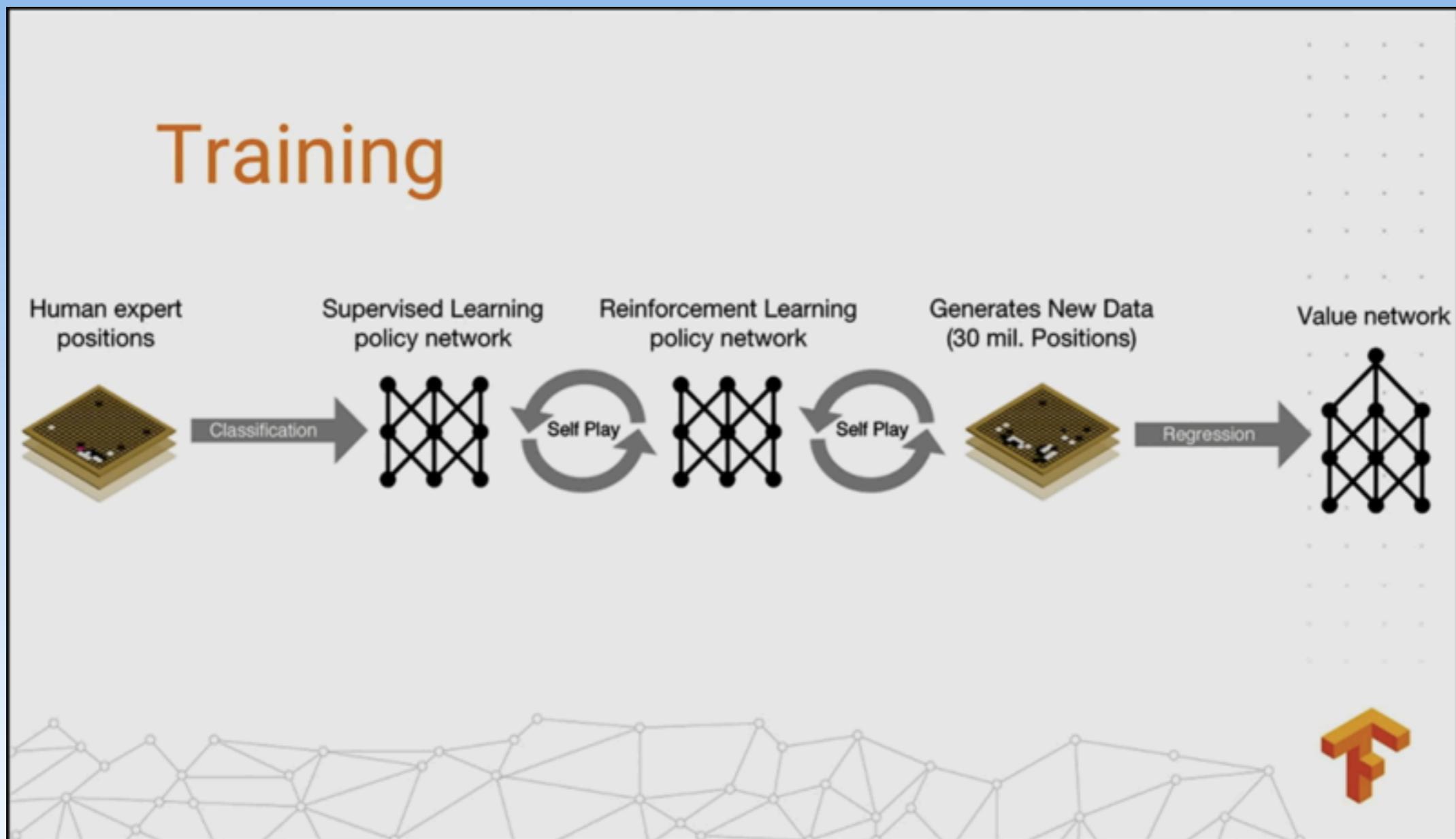
Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva^{1*}, Brett Kuprel^{1*}, Roberto A. Novoa^{2,3}, Justin Ko², Susan M. Swetter^{3,4}, Helen M. Blau⁵ & Sebastian Thrun⁶



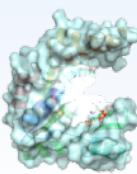
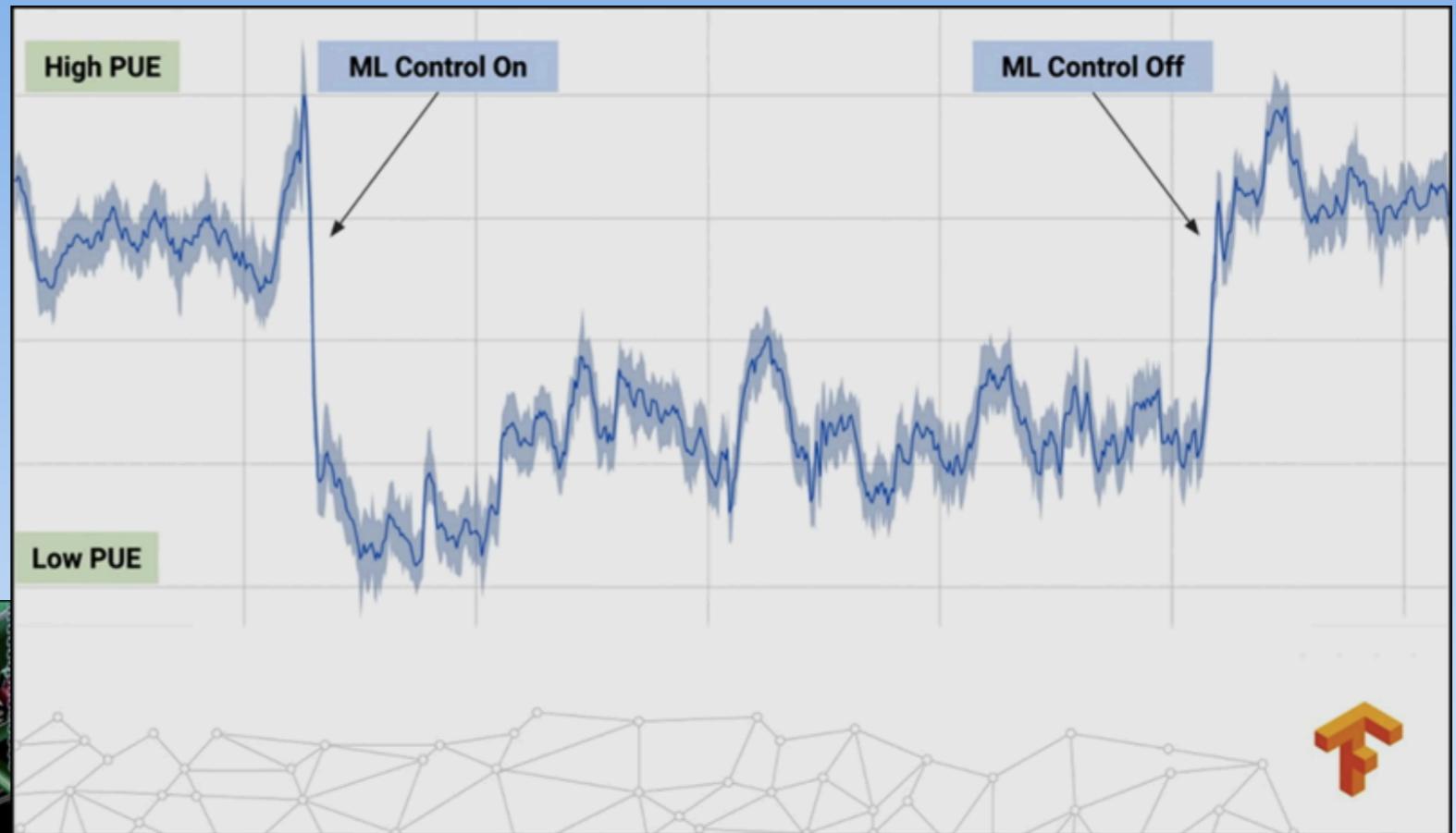
Catalit LLC

APPLICATIONS



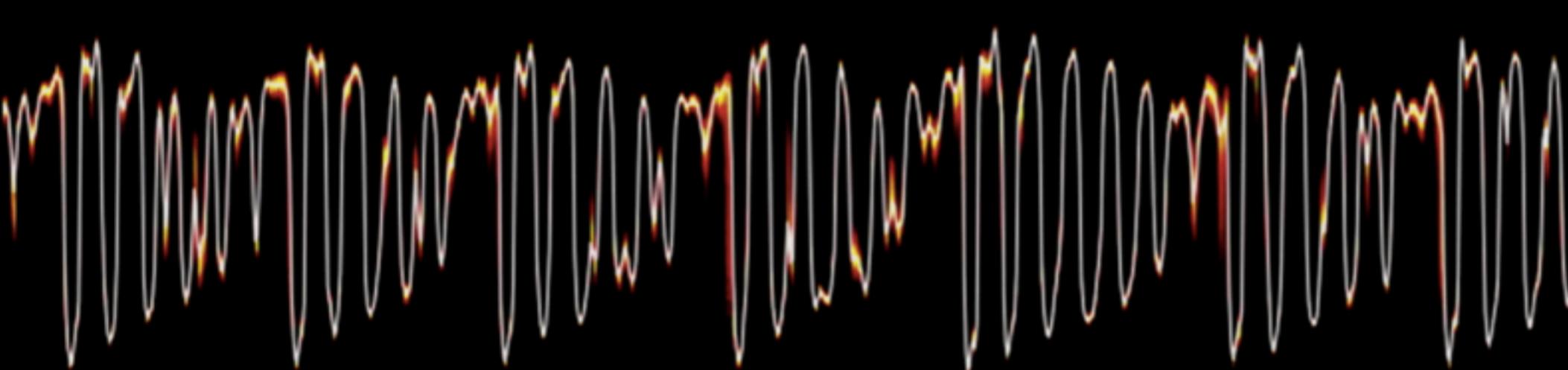
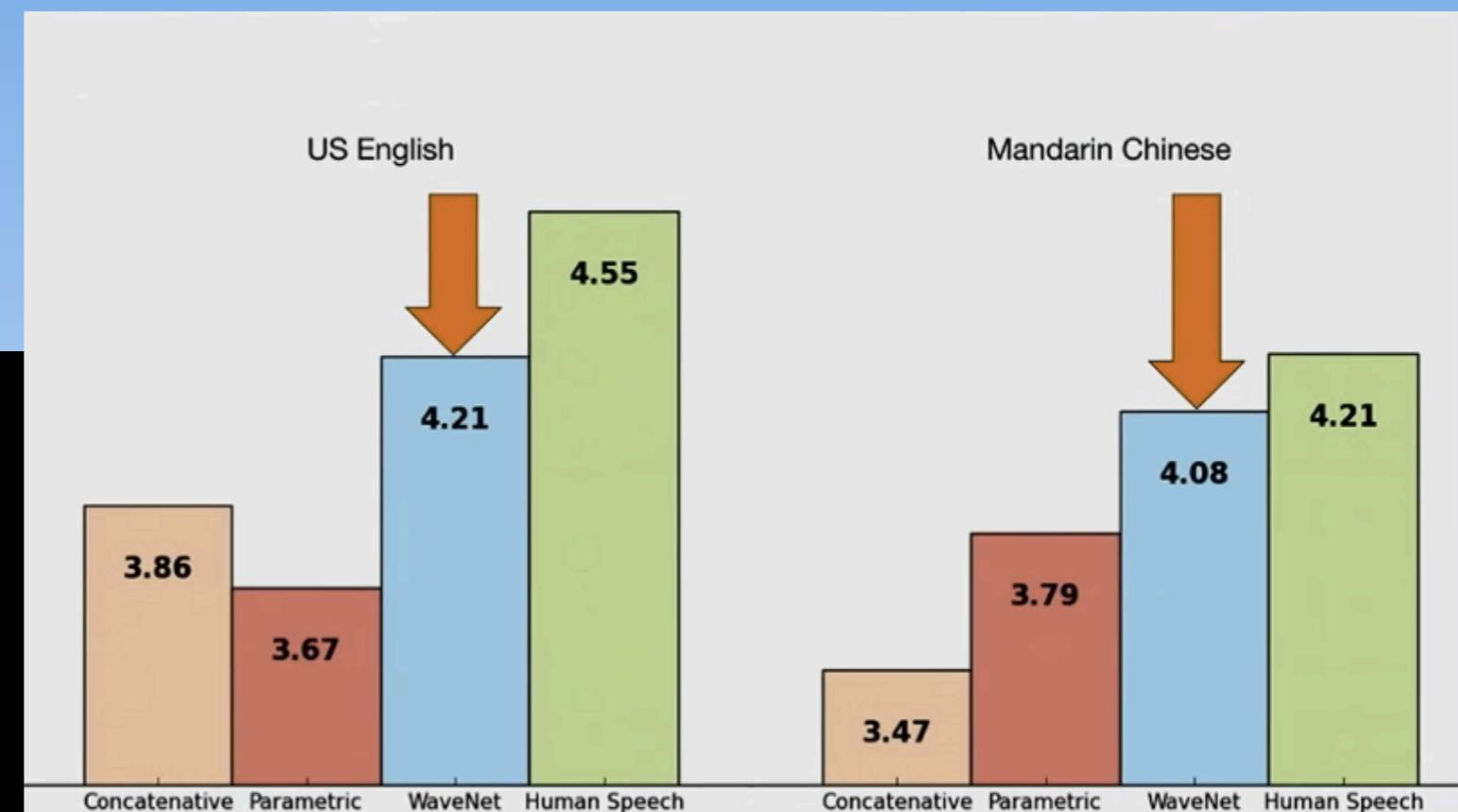
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APPLICATIONS

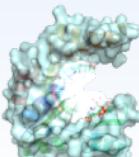


APPLICATIONS

WaveNet



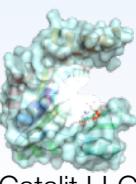
<https://deepmind.com/blog/wavenet-generative-model-raw-audio>



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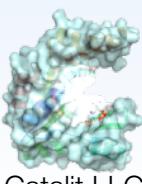
TENSORFLOW

- From Google Brain team
- Low level & Flexible
- Portable
- Auto differentiation
- Distributed



TENSORFLOW

- Framework to create computational graphs
 - Open source
 - Flexible
 - Large community

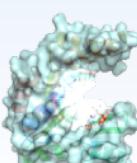


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TENSOR?

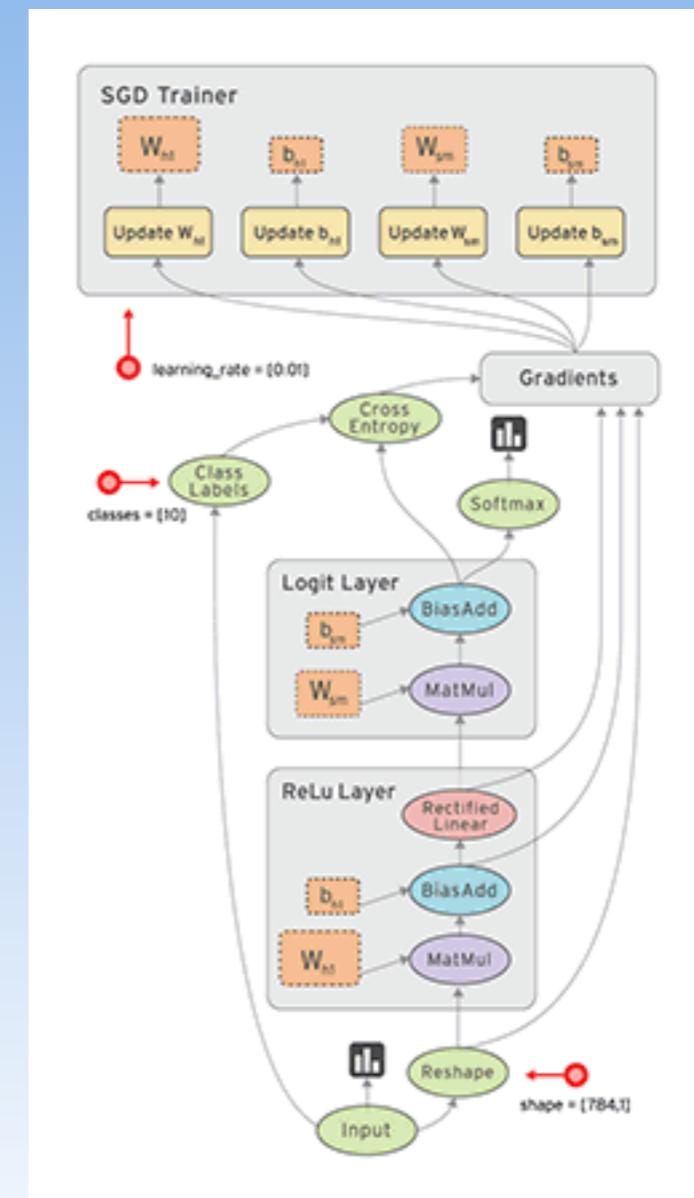
- Multidimensional array of numbers:
 - Scalar -> tensor
 - Vector -> tensor
 - Matrix -> tensor
 - ...

$$T = \begin{bmatrix} X_{11N} & X_{12N} & X_{13N} & \dots & X_{1NN} \\ X_{112} & X_{122} & X_{132} & \dots & X_{1N2} \\ X_{111} & X_{121} & X_{131} & \dots & X_{1N1} \\ X_{211} & X_{221} & X_{231} & \dots & X_{2N1} \\ \vdots & \vdots & \vdots & & \vdots \\ X_{N11} & X_{N21} & X_{N31} & \dots & X_{NN1} \end{bmatrix}$$



FLOW?

- Computations as graph
 - nodes are operations
 - edges are tensors
- 2 phases
 - construction
 - execution

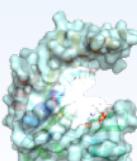
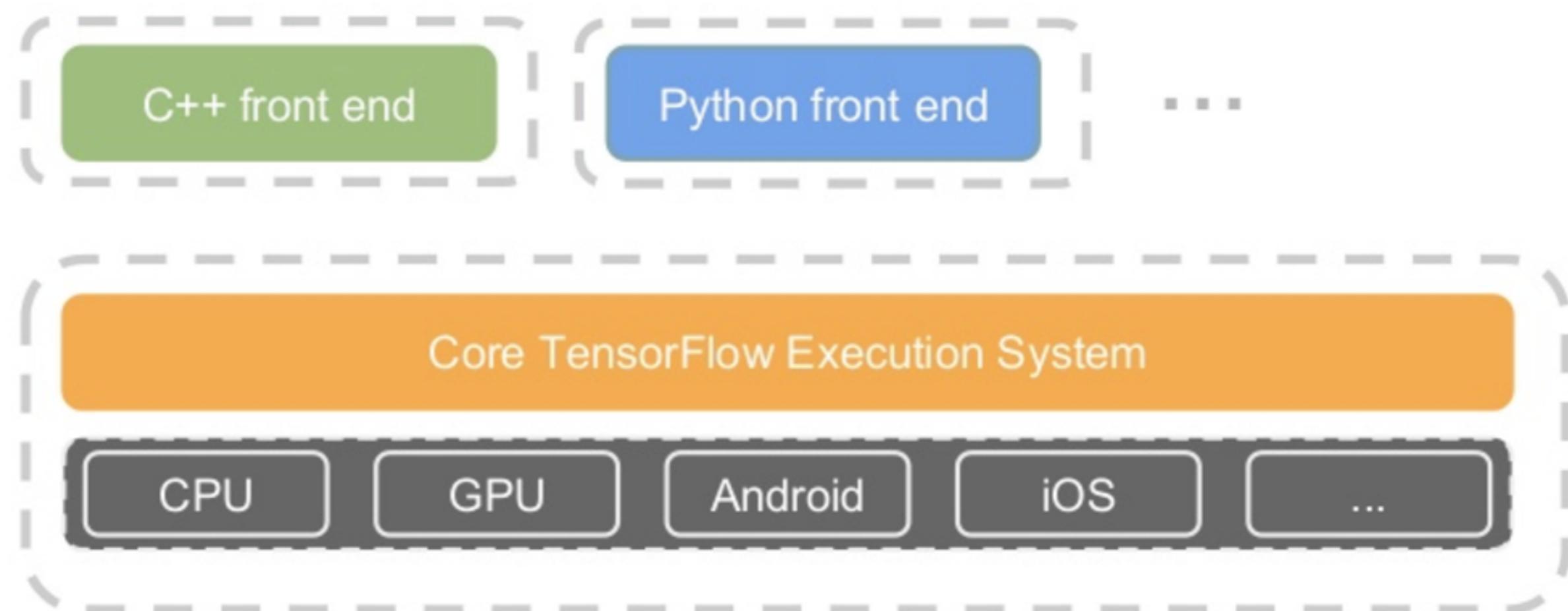


Core in C++

- Very low overhead

Different front ends for specifying/driving the computation

- Python and C++ today, easy to add more

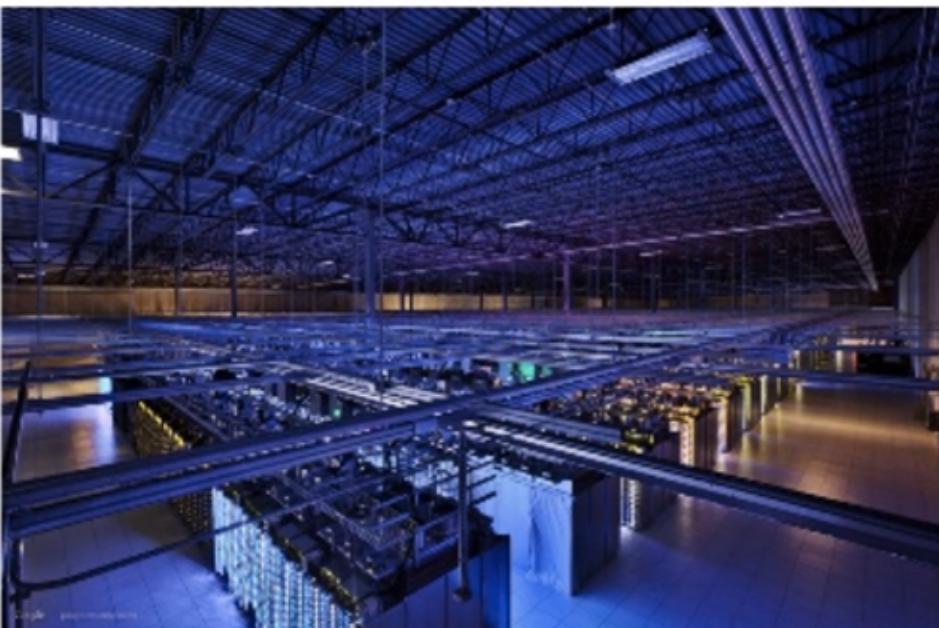


PLATFORMS

phones



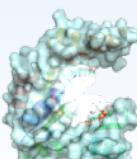
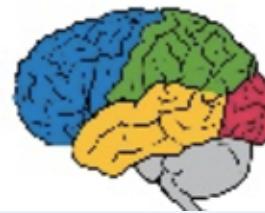
distributed systems of 100s
of machines and/or GPU cards



single machines (CPU and/or GPUs) ...



custom ML hardware



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COMMUNITY

- Recently celebrated 1 year: 11k+ commits
- 5k+ questions on stack overflow

 [tensorflow / tensorflow](#)

Code Issues 670 Pull requests 45 Projects 0 Pulse Graphs

Watch 3,569 Star 38,605 Fork 17,758

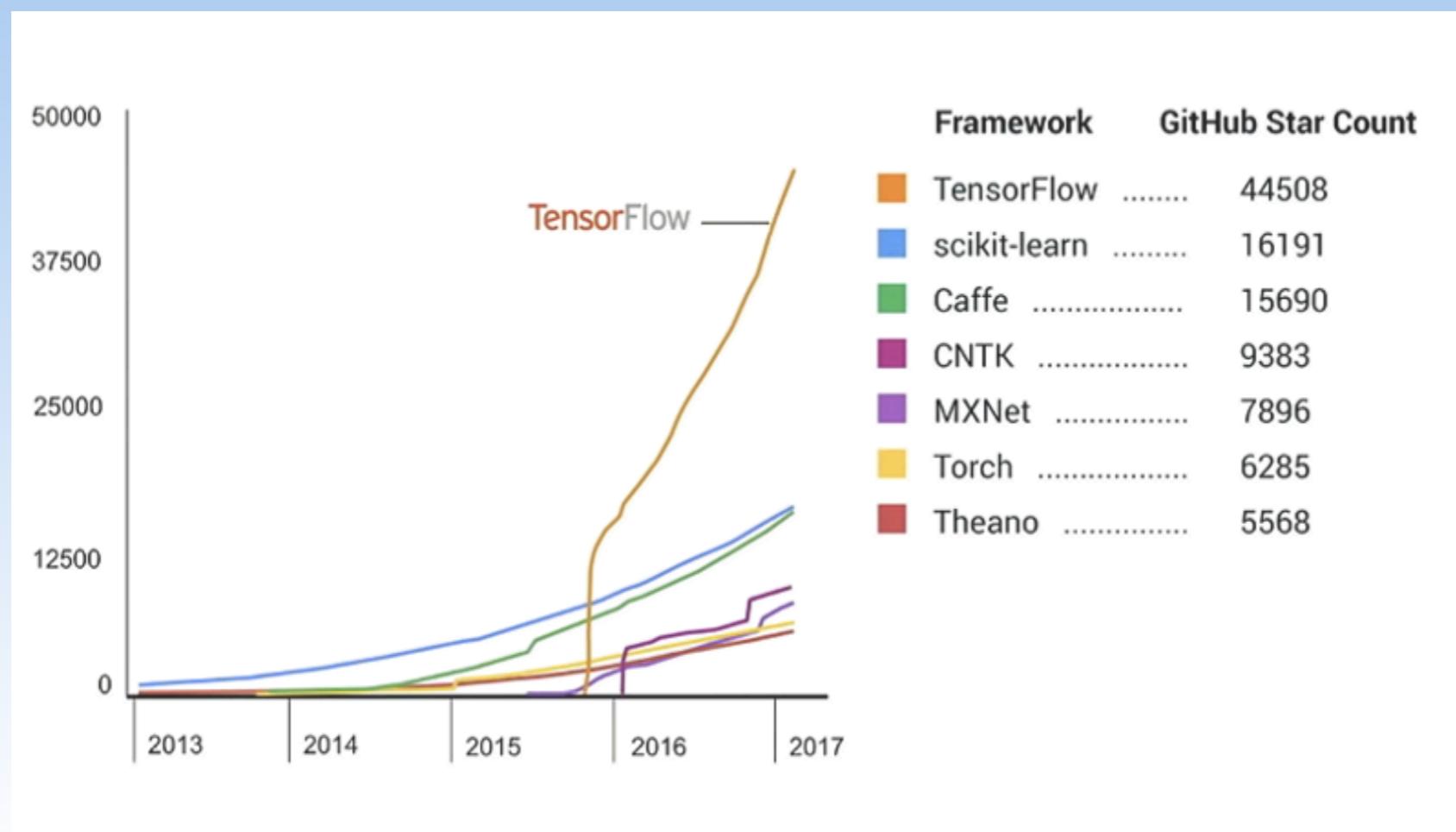
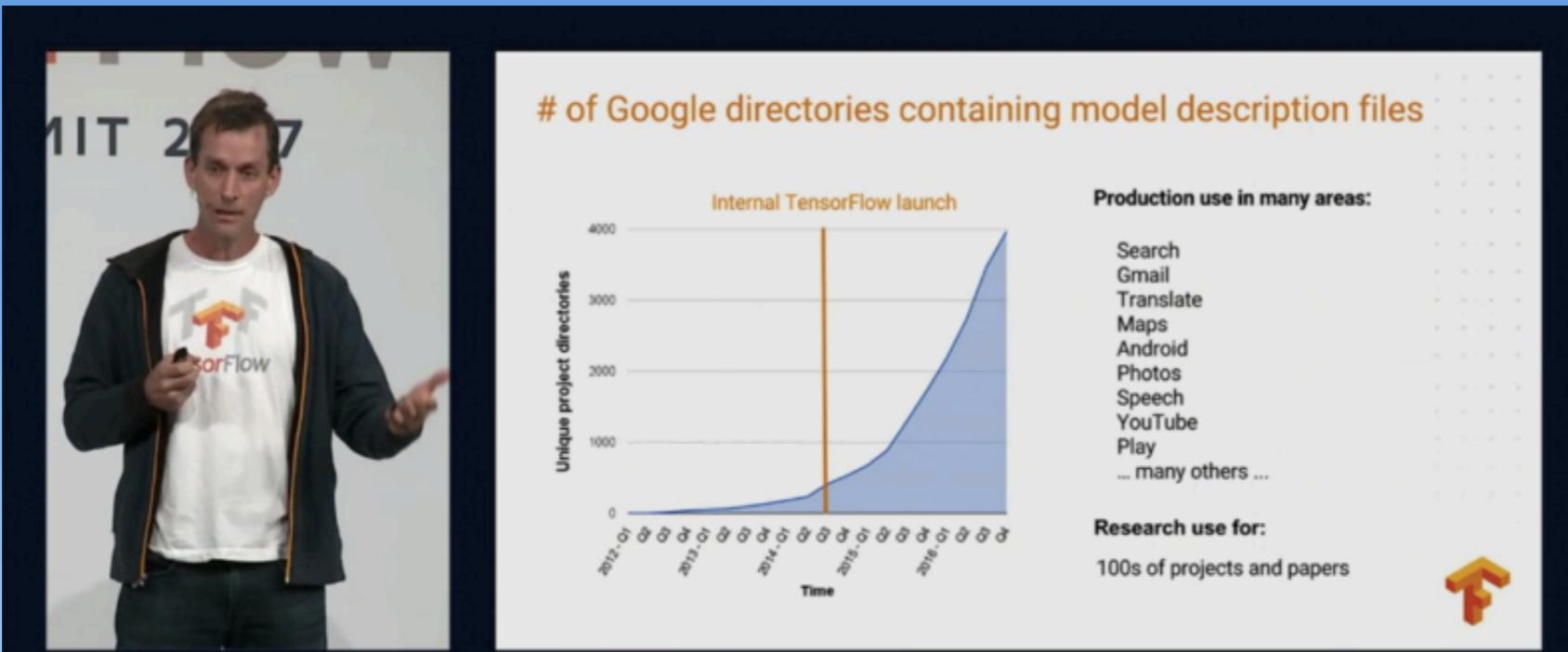
Computation using data flow graphs for scalable machine learning <http://tensorflow.org>

11,384 commits 23 branches 16 releases 532 contributors Apache-2.0

Linux CPU	Linux GPU PIP	Mac OS CPU	Windows CPU	Android
build passing	build failing	build passing	build passing	build passing



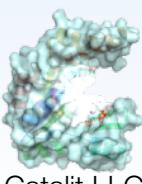
Catalit LLC

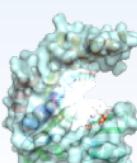
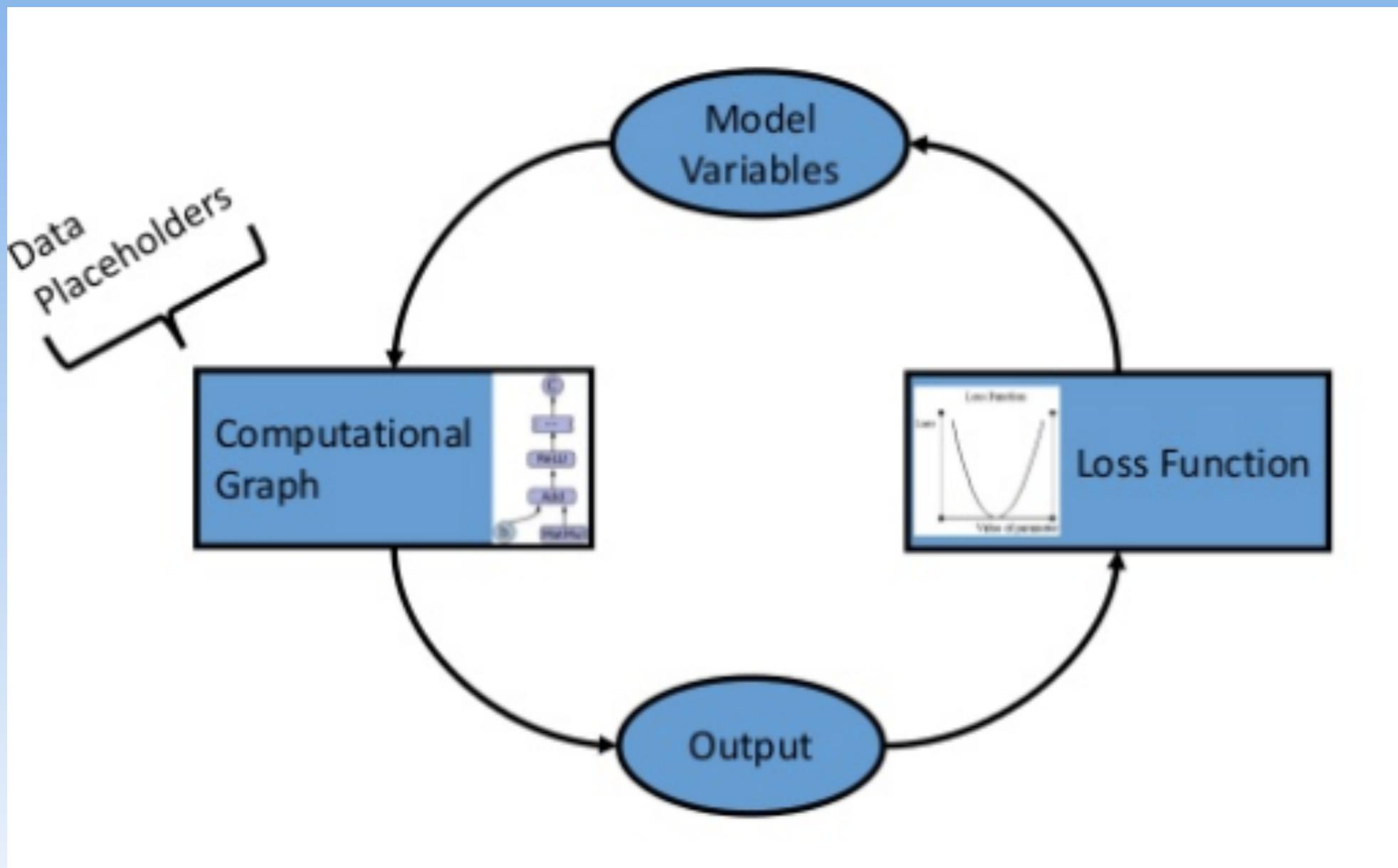


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COMPONENTS

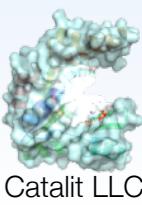
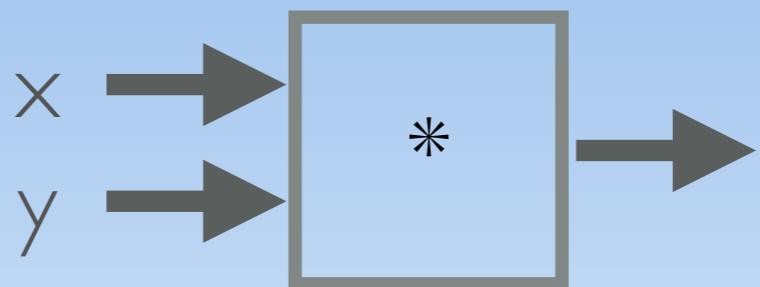
- Computational Graph
- Sessions
- Scopes, Names
- Placeholders, Variables, Feed_dict





BASIC UNIT: OP GATE

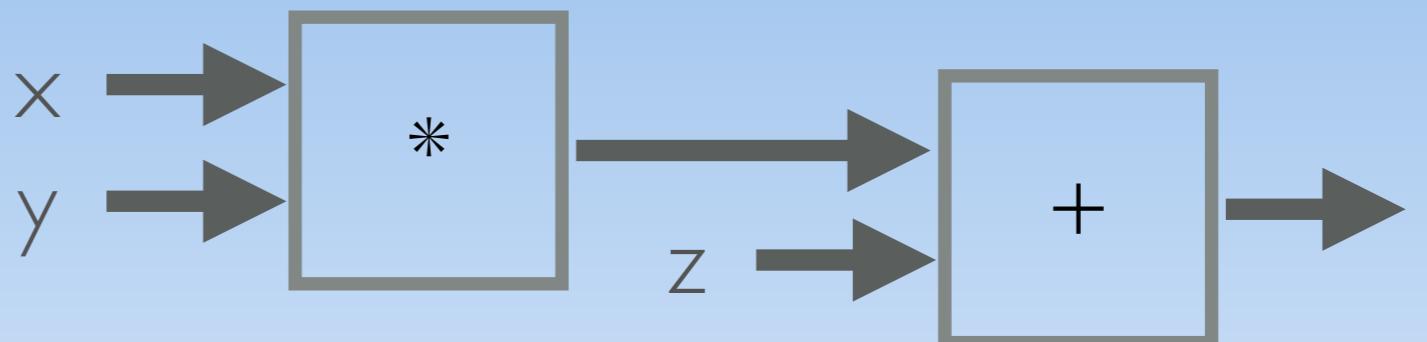
- $F(x, y) = x * y$

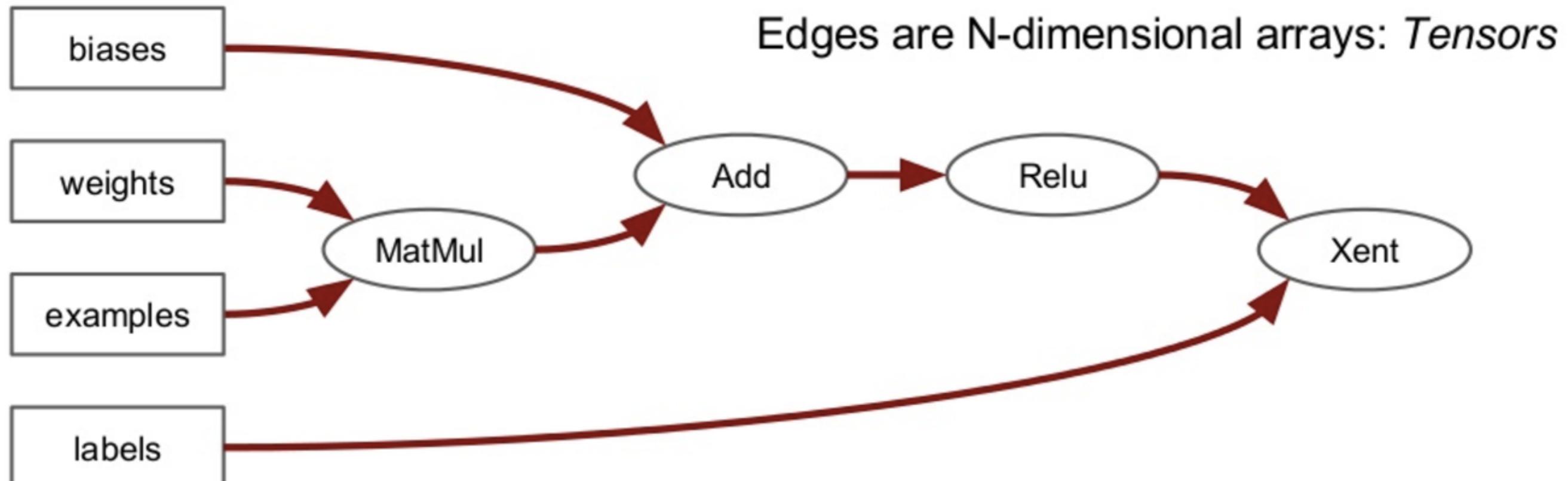


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COMPOSITION

- $F(x, y) = x * y$
- $F(x, y) = x * y + z$

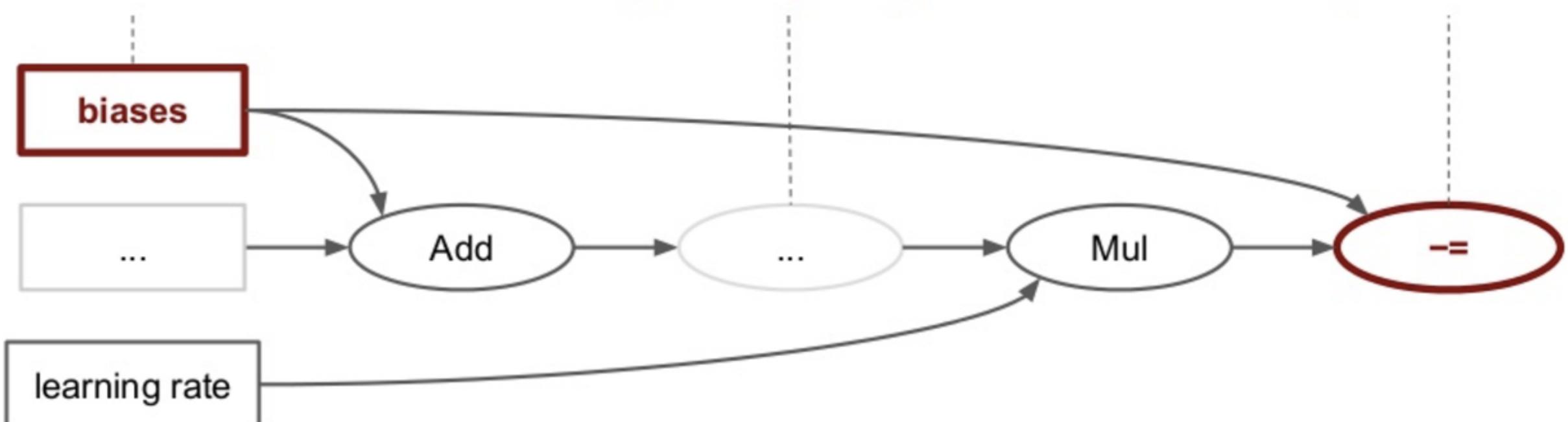




'Biases' is a variable

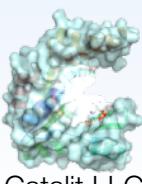
Some ops compute gradients

$\text{--} =$ updates biases



TENSOR CONVENTIONS

- Fully connected:
 - $\text{Batch_size} \times \text{Vector_length}$
 - eg. [None, 10]
- Convolutional:
 - $\text{Batch_size} \times \text{Height} \times \text{Width} \times \text{N_channels}$
 - eg. [None, 28, 28, 1]



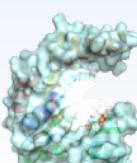
SESSIONS

- operations are "run" in a session

```
input1 = tf.placeholder(tf.float32)
input2 = tf.placeholder(tf.float32)
output = tf.mul(input1, input2)

with tf.Session() as sess:
    print(sess.run([output], feed_dict={input1:[7.], input2:[2.]}))

# output:
# [array([ 14.], dtype=float32)]
```

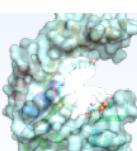
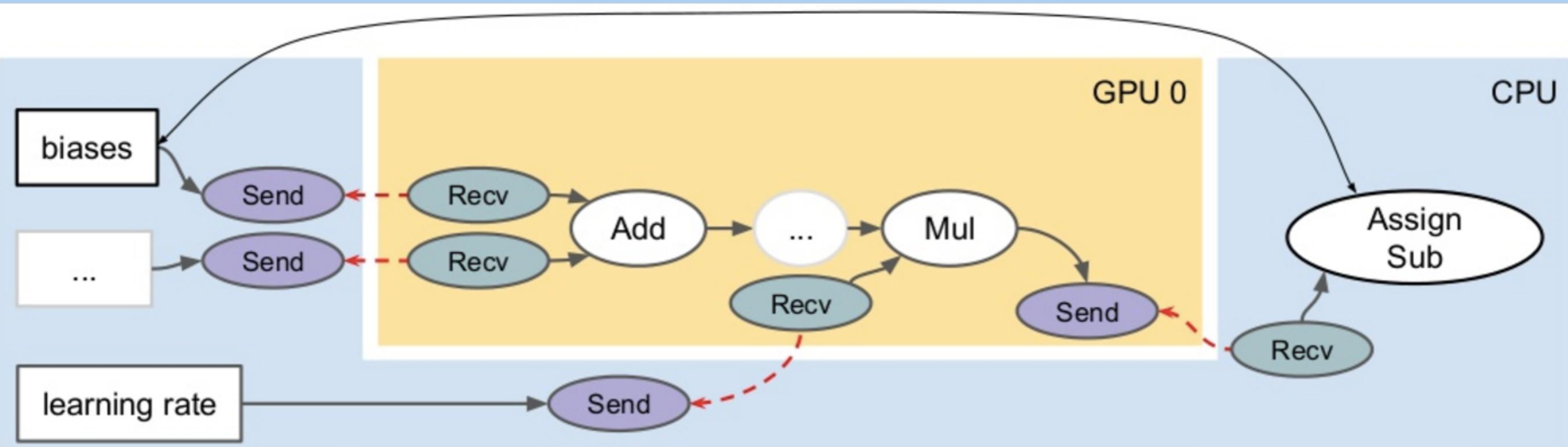


DISTRIBUTED

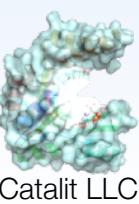
```
with tf.Session("grpc://example.org:2222") as sess:  
    # Calls to sess.run(...) will be executed on the cluster.  
    ...
```

```
with tf.device("/job:ps/task:0"):  
    weights = tf.Variable(...)  
    biases = tf.Variable(...)
```

```
with tf.Session() as sess:  
    with tf.device("/gpu:1"):  
        matrix1 = tf.constant([[3., 3.]])  
        matrix2 = tf.constant([[2.],[2.]])  
        product = tf.matmul(matrix1, matrix2)  
        ...
```



LAB



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