Introduction to TensorFlow

...

Alejandro Solano - EuroPython 2017


TensorFlow

cat

input

target

??

cat

input

sin

\+

x

log

exp

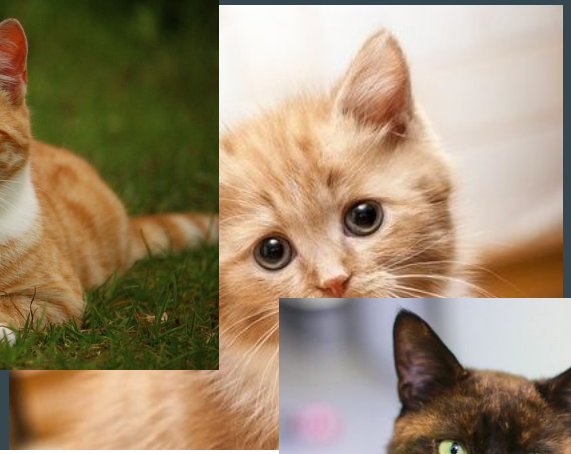
target

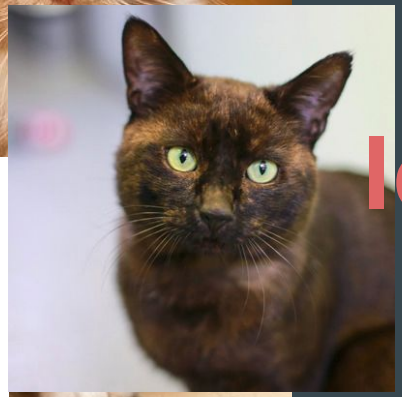
cat

TensorFlow

input

target





sin

\+

x

log

exp

cat

TensorFlow

Deep Learning

What is TensorFlow?

- TensorFlow is an open-source library for Deep Learning.
- Developed by the Google Brain team and released in November 2015.
- Version 1.0.0 was launched in February 2017.

Installation

Install TensorFlow (Linux and Mac OS)

- Download Anaconda
- Create an environment with all must-have libraries.

```
$ conda create -n tensorflow python=3.5
$ source activate tensorflow
$ conda install pandas matplotlib jupyter notebook scipy scikit
$ pip install tensorflow
```

Install TensorFlow (Windows)

- Download Anaconda
- Create an environment with all must-have libraries.

```
$ conda create -n tensorflow python=3.5
$ activate tensorflow
$ conda install pandas matplotlib jupyter notebook scipy scikit
$ pip install tensorflow
```

Concepts

cat

TensorFlow

MODEL

cat

TensorFlow

MODEL

non-cat

TensorFlow

MODEL

prediction

non-cat

target

cat

input

TensorFlow

MODEL

non-cat

C
O
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T

cat

TensorFlow

MODEL

non-cat

C
O
S
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error

cat

TensorFlow

MODEL

non-cat

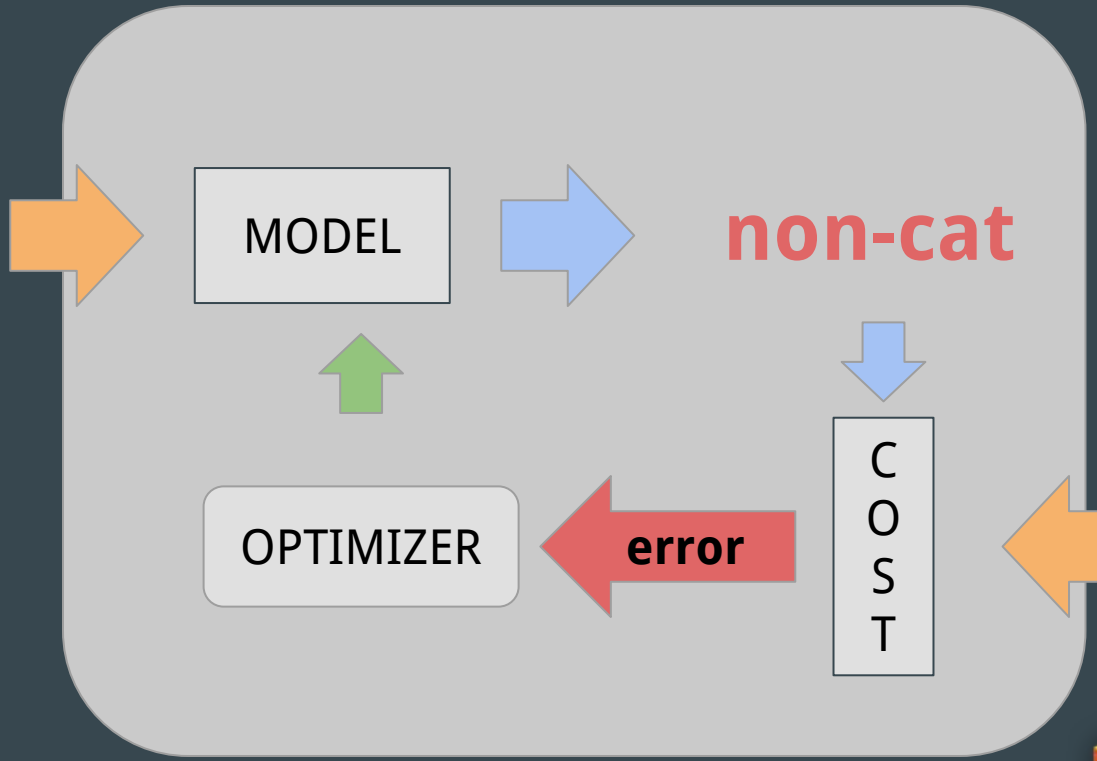
C
O
S
T

cat

error

OPTIMIZER

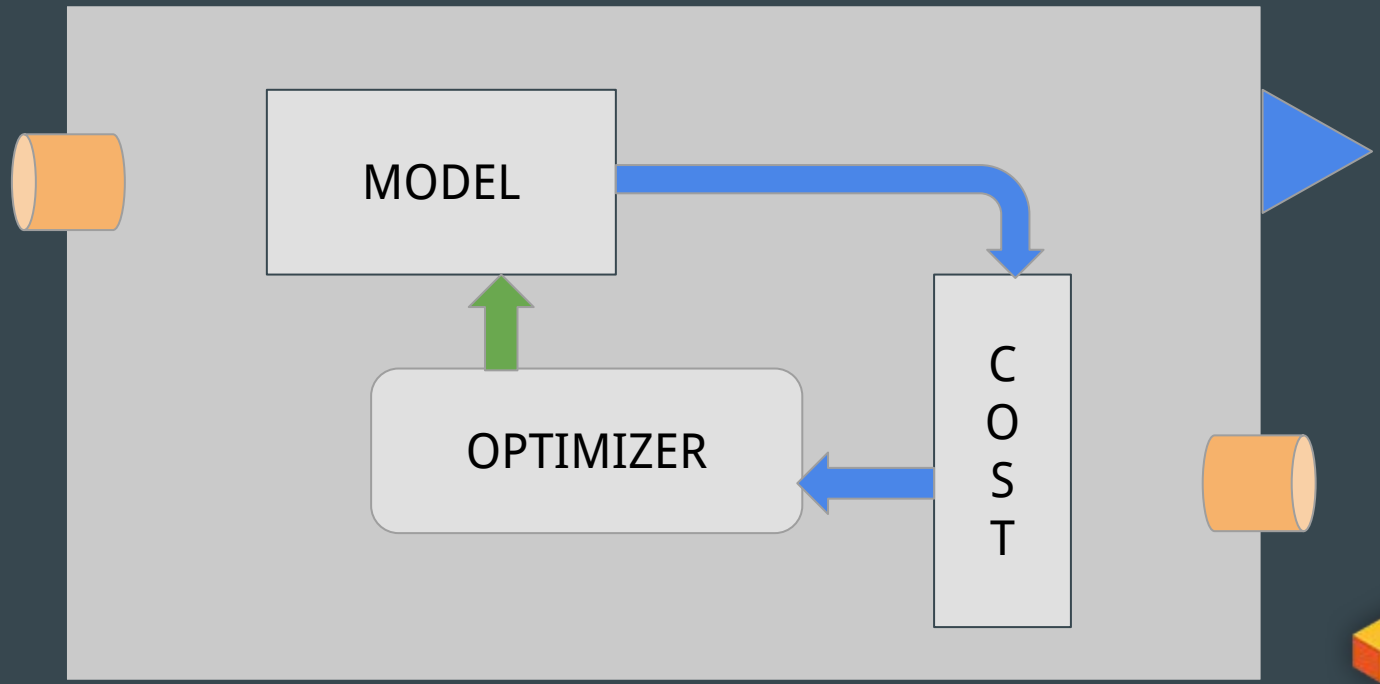
TensorFlow



Graph

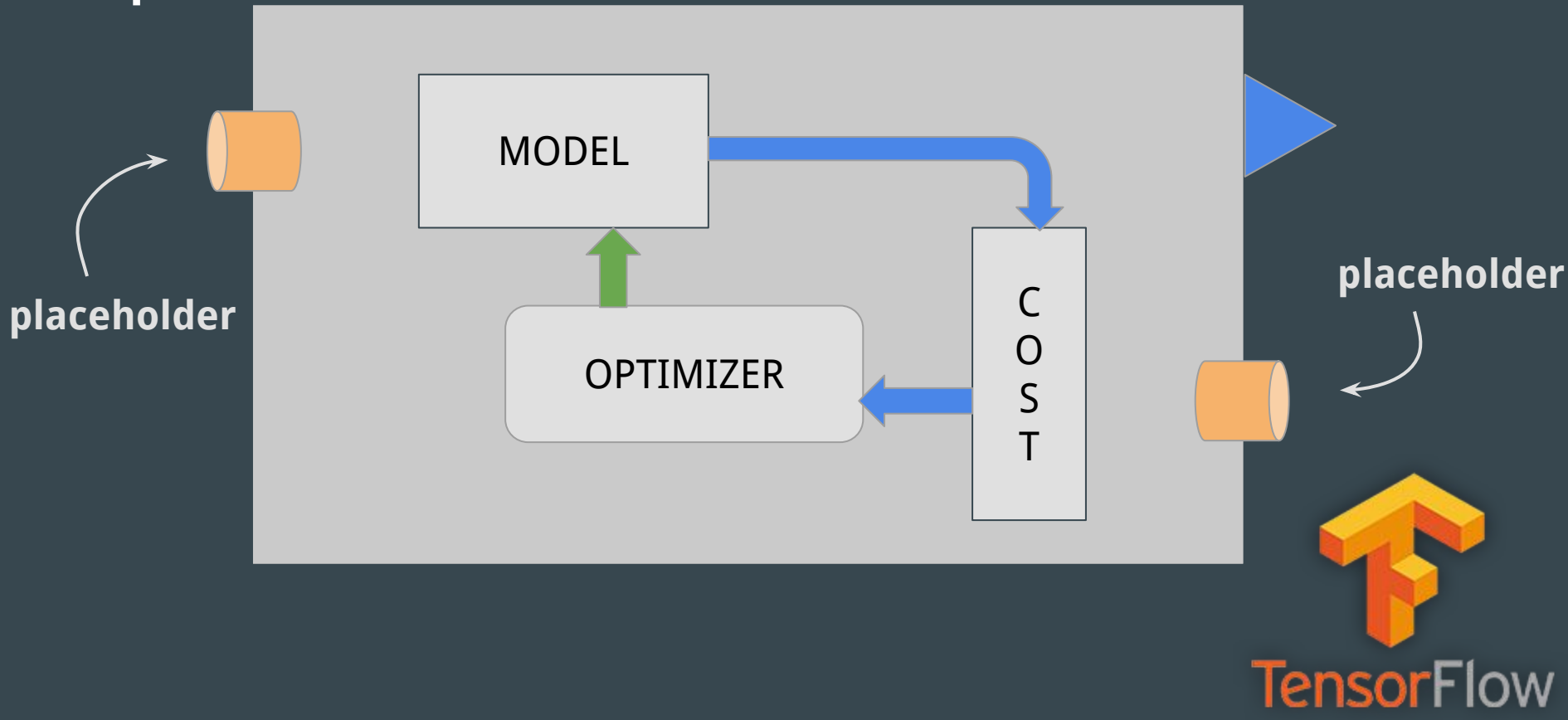
TensorFlow

Graph



TensorFlow

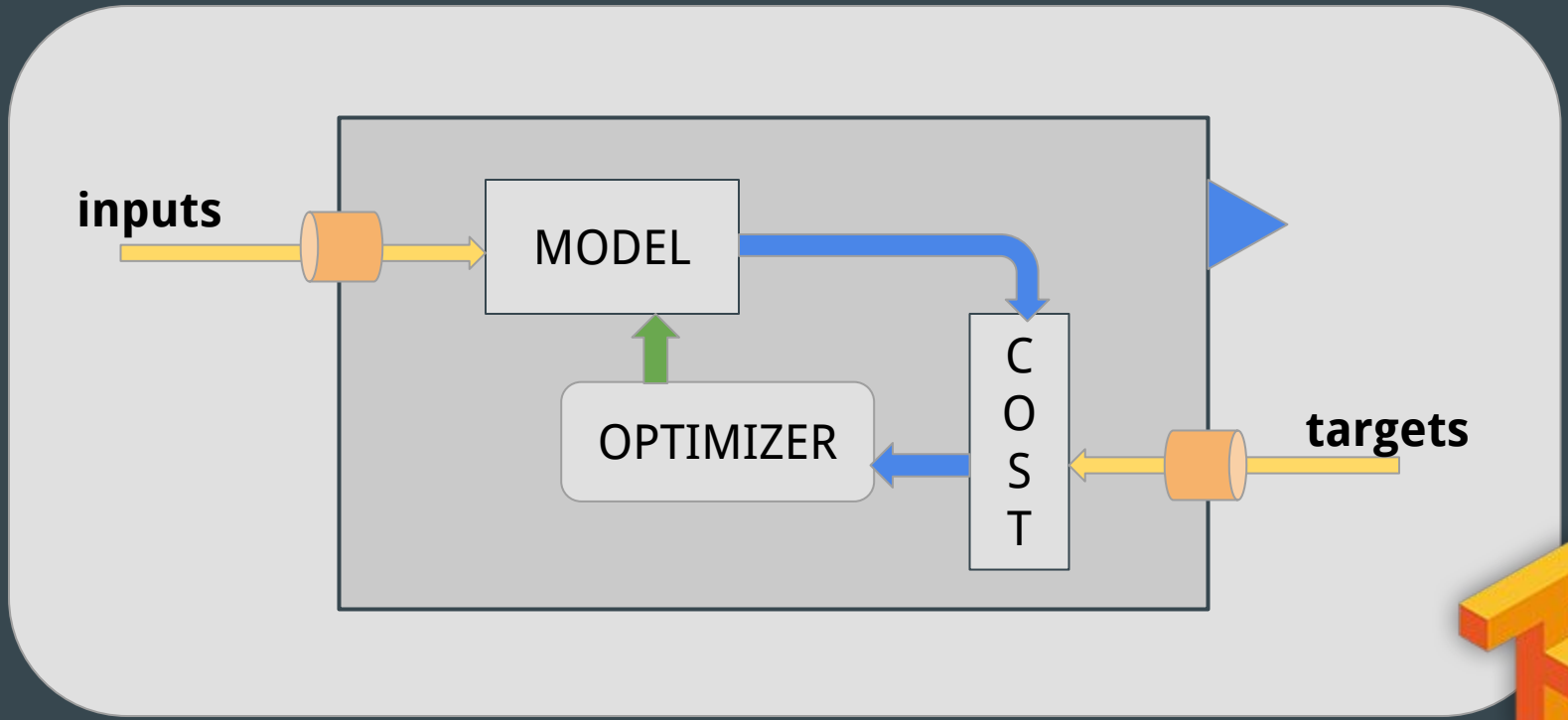
Graph


MODEL
placeholder
OPTIMIZER
C
O
S
T
placeholder
TensorFlow

Graph

- **Placeholders:** gates where we introduce example
- **Model:** makes predictions. Set of **variables** and operations
- **Cost function:** function that computes the model error
- **Optimizer:** algorithm that optimizes the variables so the cost would be zero

Session: Graph + Data



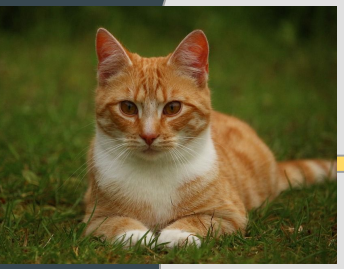
TensorFlow

Graph, Data and Session

- **Graph:** Layout of the prediction and learning process. It does not include data.
- **Data:** examples that will train the neural network. It consists on two kinds: inputs and targets.
- **Session:** where everything takes places. Here is where we **feed** the graph with data.

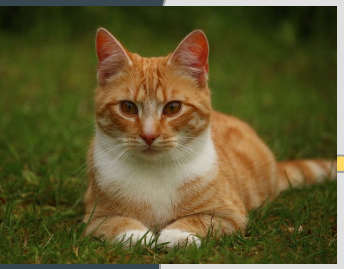
TensorFlow

Session: Graph + Data



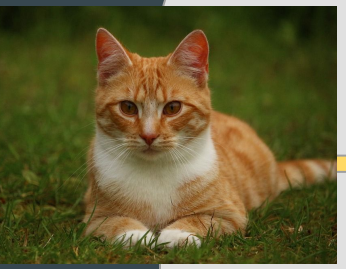
TensorFlow

Session: Graph + Data



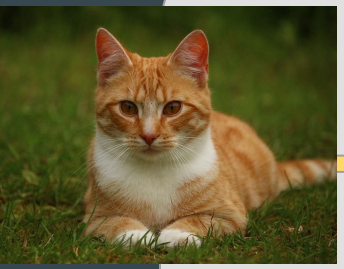
TensorFlow

Session: Graph + Data



TensorFlow

Session: Graph + Data



MODEL

non-cat

train

OPTIMIZER

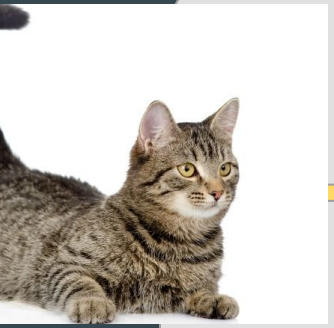
100

COST

cat

TensorFlow

Session: Graph + Data



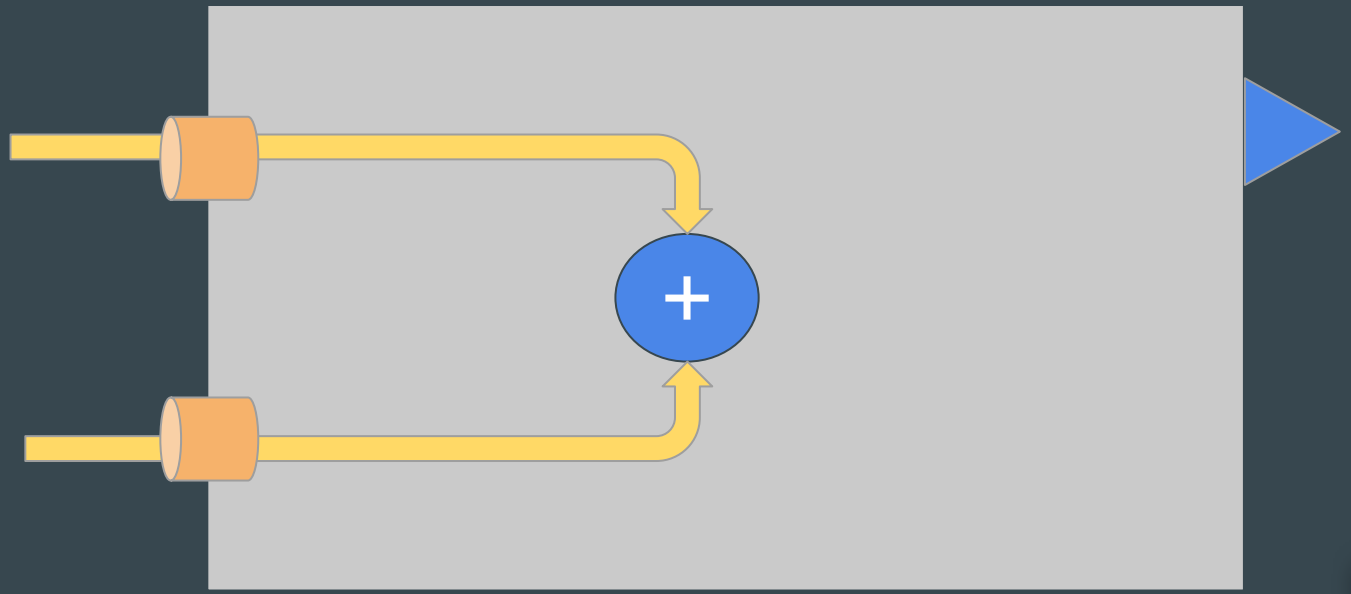
TensorFlow

Hello world!

Hello world!: Sum of two integers

```
import tensorflow as tf
```

Hello world!: Sum of two integers



TensorFlow

Hello world!: Sum of two integers

```
##### GRAPH #####
a = tf.placeholder(tf.int32)
b = tf.placeholder(tf.int32)
sum_graph = tf.add(a, b)

##### DATA #####
num1 = 3
num2 = 8
```

Hello world!: Sum of two integers

```
##### SESSION #####
with tf.Session() as sess:
    sum_outcome = sess.run(sum_graph, feed_dict={
        a: num1,
        b: num2
        })
```

In [5]:
```
with tf.Session() as sess:
    sum_output = sess.run(sum_graph, feed_dict={
        a: num1,
        b: num2
        })

    print("The sum of {} and {} is {}".format(num1, num2, sum_output))
```

```
The sum of 3 and 8 is 11
```

Regression

TensorFlow for Regression: learning how to sum

- Mission: learn how to sum using 10,000 examples.

$$x_1 + x_2 = y$$

TensorFlow for Regression: learning how to sum

- Mission: learn how to sum using 10,000 examples.

$$x_1 \; ? \; x_2 = y$$

TensorFlow for Regression: learning how to sum

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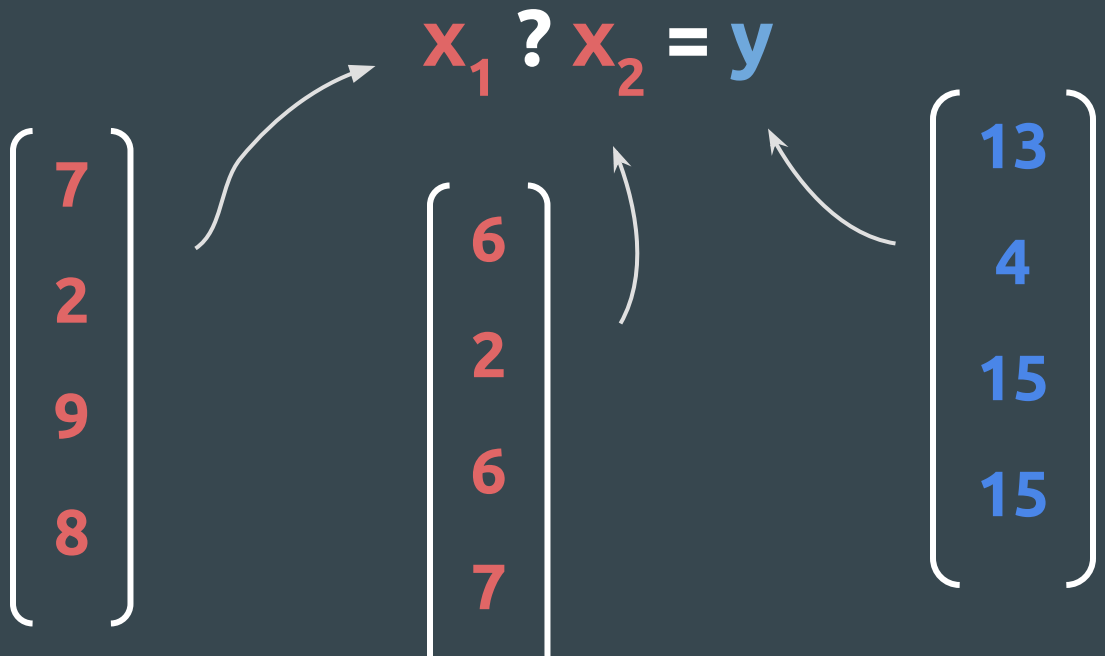

TensorFlow

TensorFlow for Regression: learning how to sum

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$x_1 \; ? \; x_2 = y$

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TensorFlow

TensorFlow for Regression: learning how to sum

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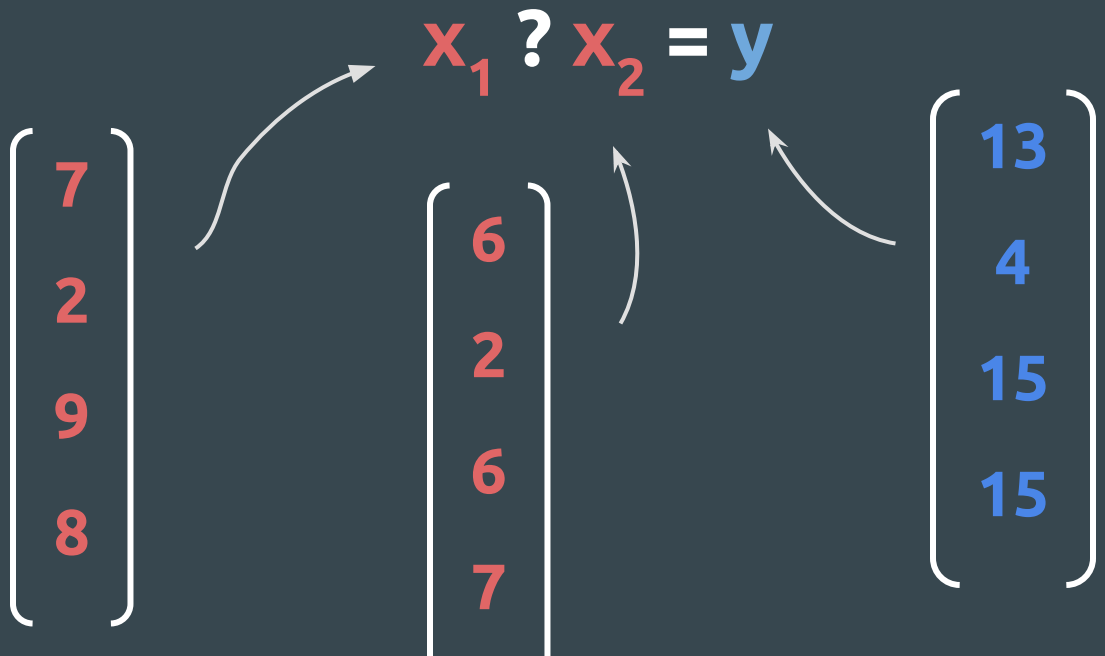

TensorFlow

TensorFlow for Regression: learning how to sum

- Mission: learn how to sum using 10,000 examples.

$$x_1 \; ? \; x_2 = y$$

- We assume the relationship between **x** and **y** is a linear function.

$$x \cdot W + b = y$$

TensorFlow for Regression: learning how to sum

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$$x_1 \; ? \; x_2 = y$$

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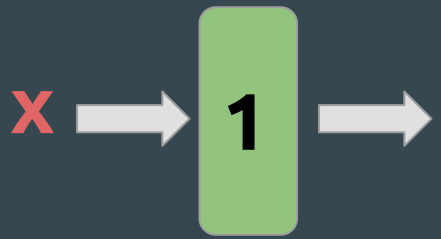
$$x \cdot W + b = y$$

variables to be learned

Neural Network

$$x \cdot W_1 + b_1 = y$$

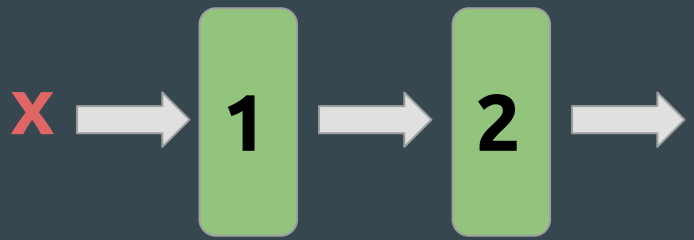


TensorFlow

Neural Network

$$x \cdot W_1 + b_1 = y$$

$$(x \cdot W_1 + b_1) \cdot W_2 + b_2 = y$$



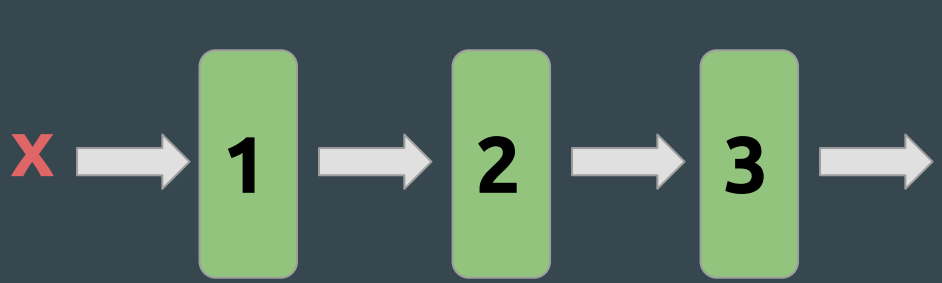
TensorFlow

Neural Network

$$x \cdot W_1 + b_1 = y$$

$$(x \cdot W_1 + b_1) \cdot W_2 + b_2 = y$$

$$((x \cdot W_1 + b_1) \cdot W_2 + b_2) \cdot W_3 + b_3 = y$$



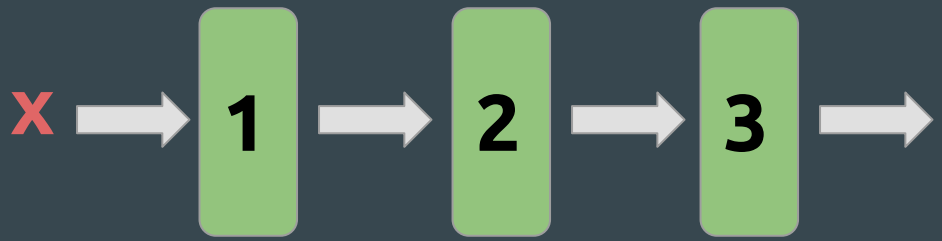
TensorFlow

Neural Network

$$x \cdot W_1 + b_1 = y$$

$$\sigma(x \cdot W_1 + b_1) \cdot W_2 + b_2 = y$$

$$\tanh(\sigma(x \cdot W_1 + b_1) \cdot W_2 + b_2) \cdot W_3 + b_3 = y$$



TensorFlow

TensorFlow for Regression: learning how to sum

```
# PLACEHOLDERS
x = tf.placeholder(tf.float32, [None, 2])
y = tf.placeholder(tf.float32, [None, 1])
```

TensorFlow for Regression: learning how to sum

```
# PLACEHOLDERS
x = tf.placeholder(tf.float32, [None, 2])
y = tf.placeholder(tf.float32, [None, 1])
```

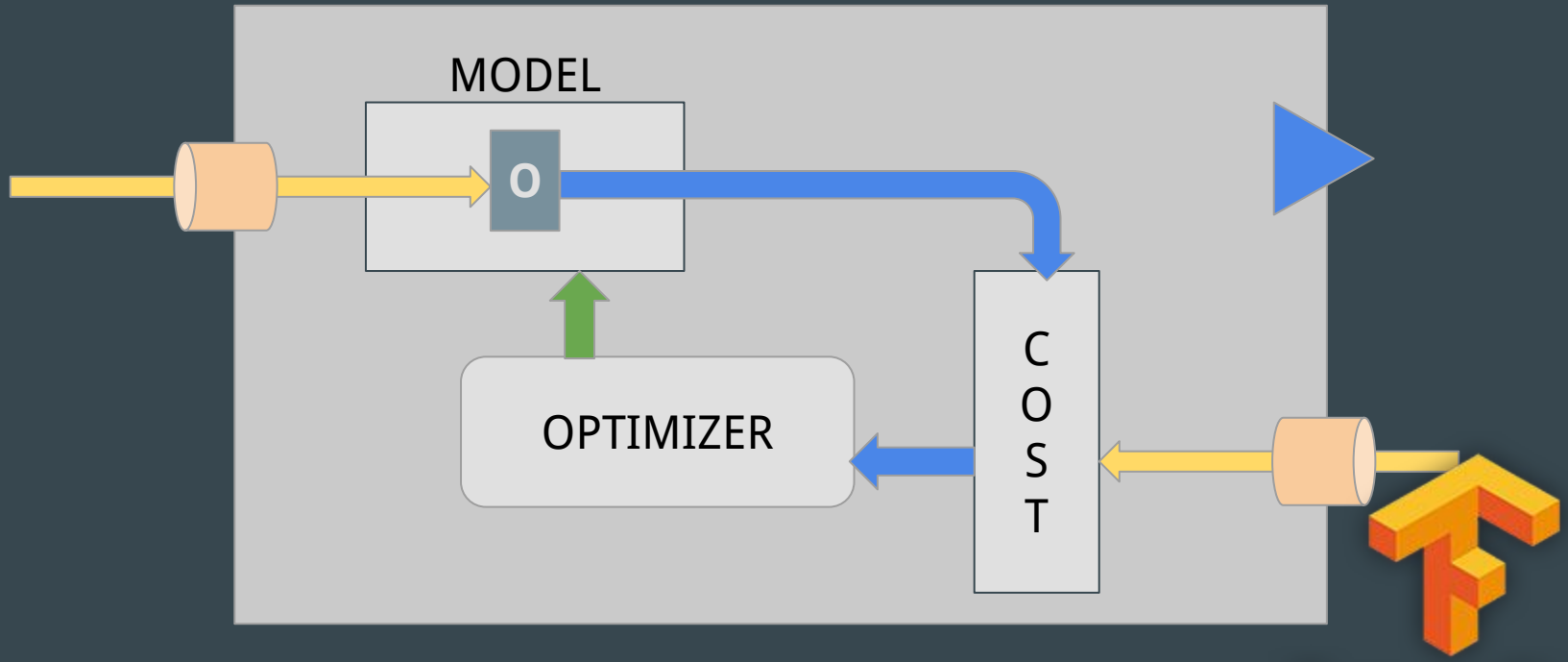
(we don't know how many examples we'll have, but we do know that each one of them has 2 numbers as input and 1 as target)

TensorFlow for Regression: learning how to sum

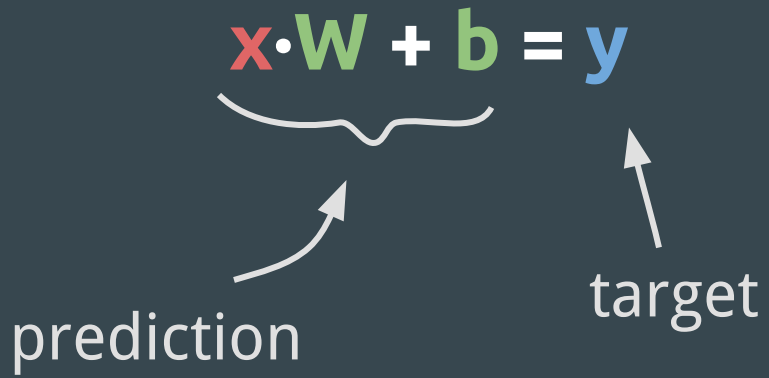
```
# MODEL
W = tf.Variable(tf.truncated_normal([2, 1], stddev=0.05))
b = tf.Variable(tf.random_normal([1]))

output = tf.add(tf.matmul(x, W), b)
```

TensorFlow for Regression: learning how to sum



Cost (loss) function



TensorFlow

Cost (loss) function

$$y - (x \cdot W + b)$$

Cost (loss) function

$$[\, y - (\, x \cdot W + b \,) \,]^2$$

Cost (loss) function

$$\Sigma[\, y_i - (\, x_i \cdot W + b \,)\,]^2$$

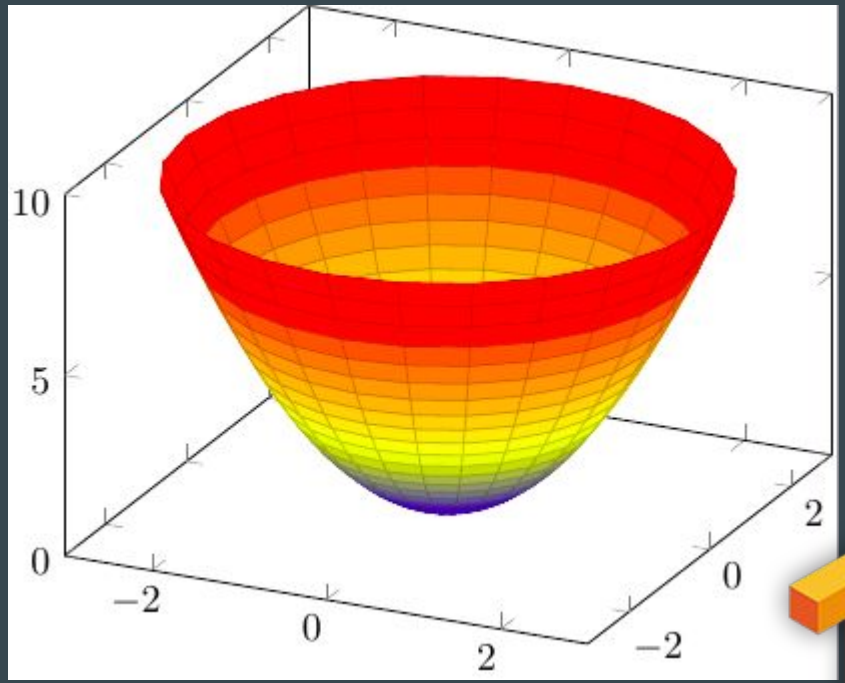
TensorFlow for Regression: learning how to sum

```
cost = tf.reduce_sum(tf.square(output - y))
```

Gradient Descent

cost function

```
cost = f(w1, w2, b)
```

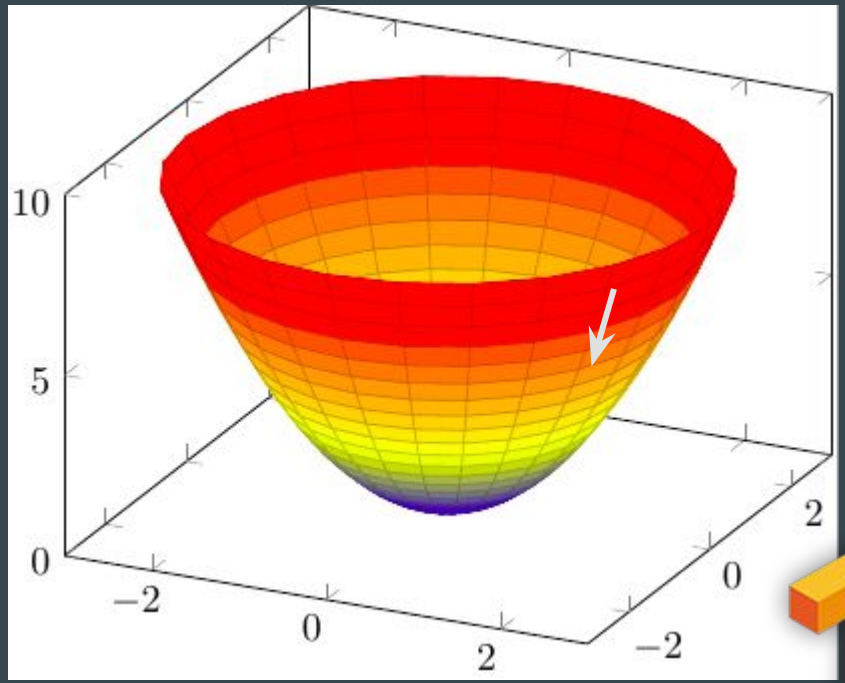


TensorFlow

Gradient Descent

cost function

```
cost = f(w1, w2, b)
```



TensorFlow

Gradient Descent

cost function

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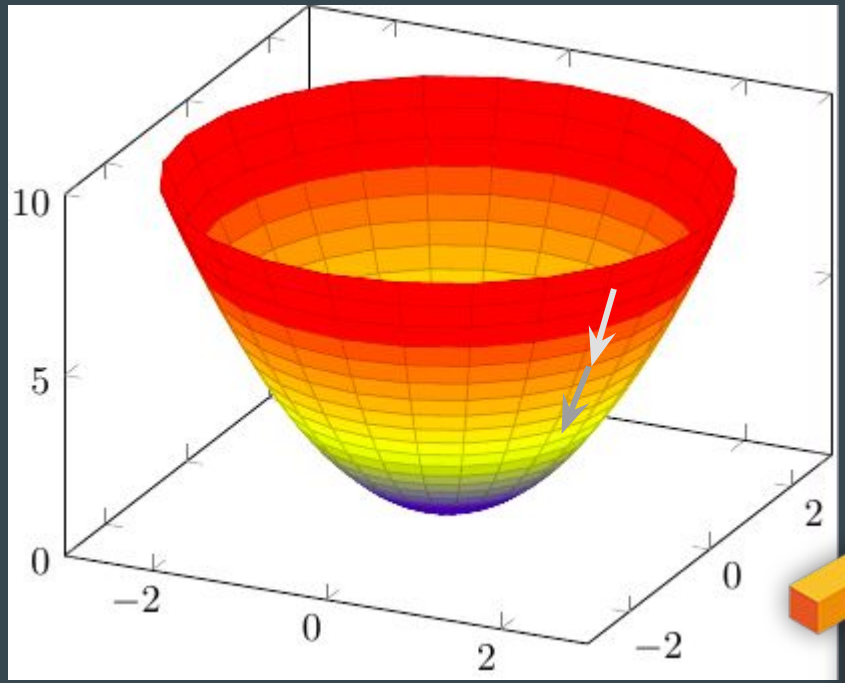
cost = f(w1, w2, b)
```



TensorFlow

Gradient Descent

cost function

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cost = f(w1, w2, b)
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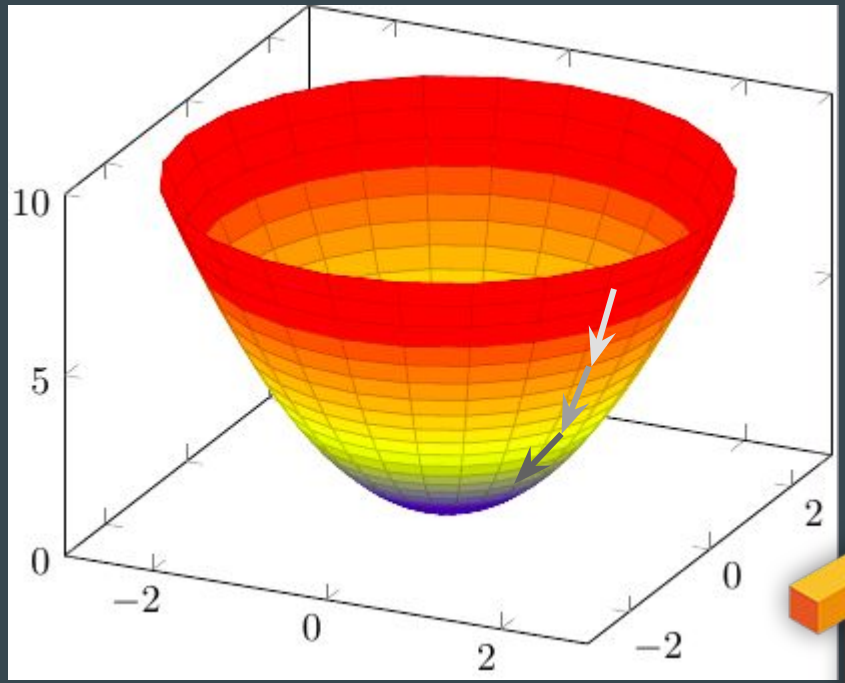


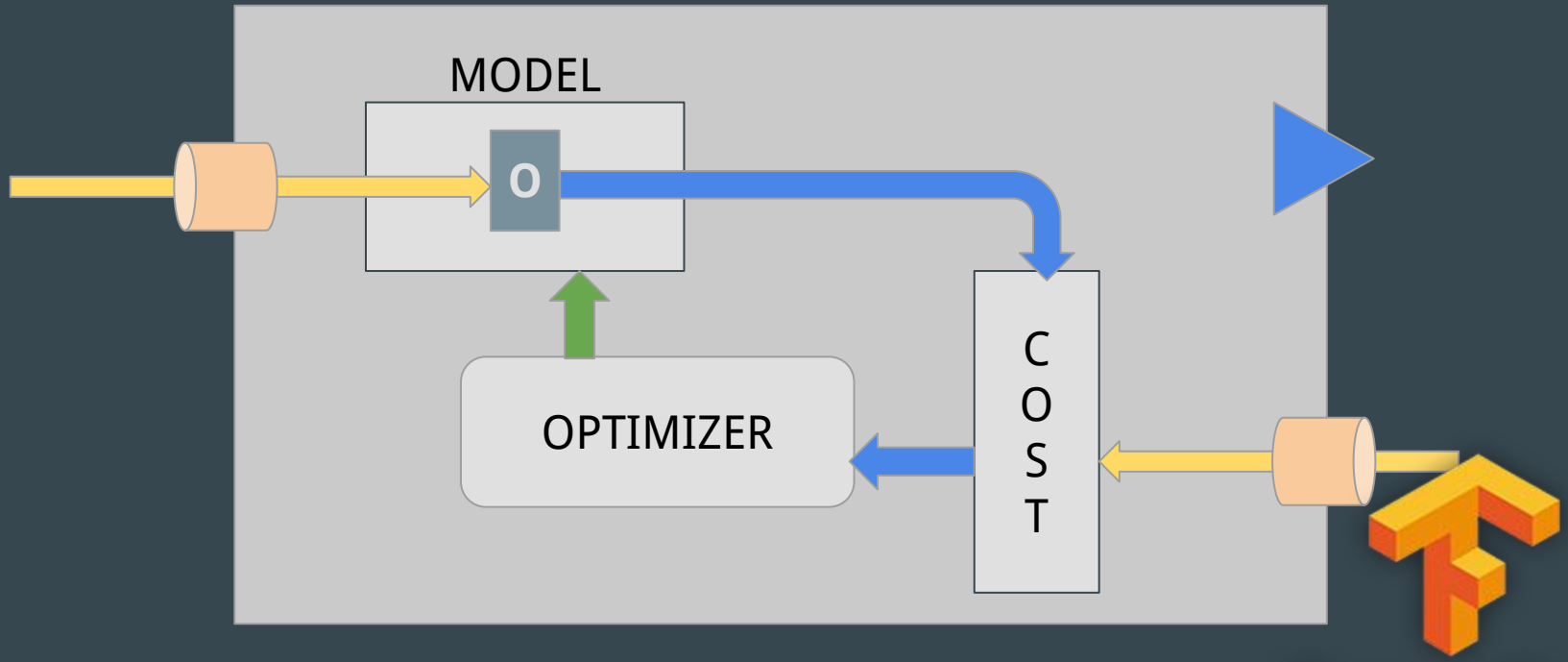
TensorFlow

TensorFlow for Regression: learning how to sum

```
optimizer =
tf.train.GradientDescentOptimizer(learning_rate=0.00001)

optimizer = optimizer.minimize(cost)
```

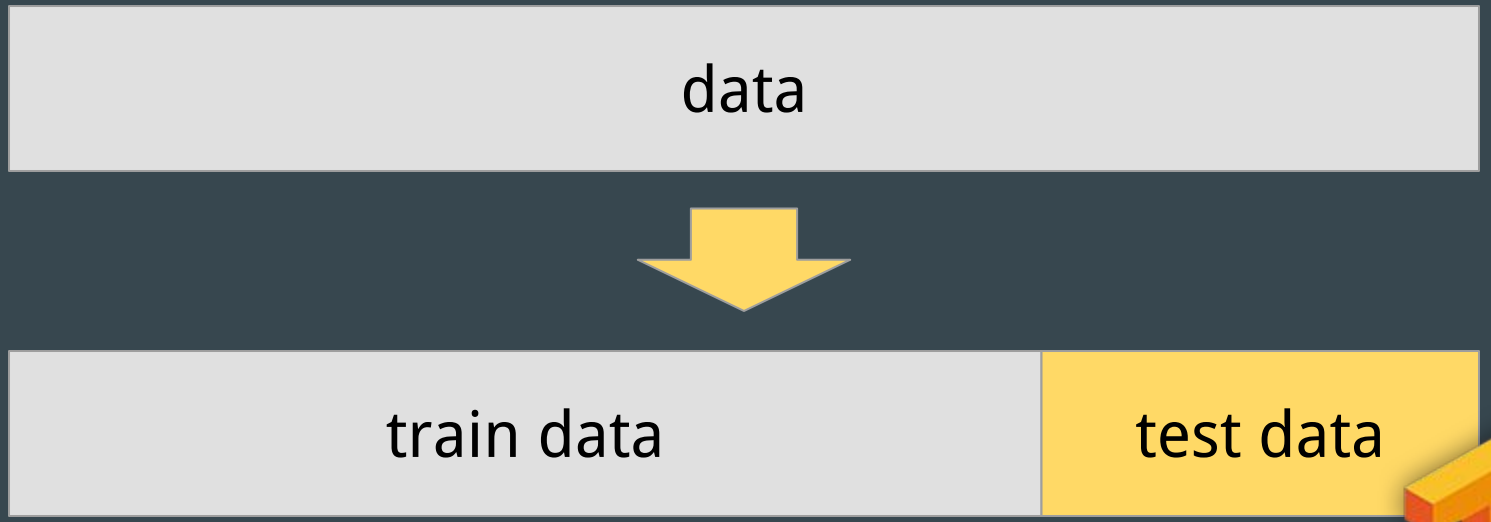
TensorFlow for Regression: learning how to sum



Data split

data

Data split



TensorFlow

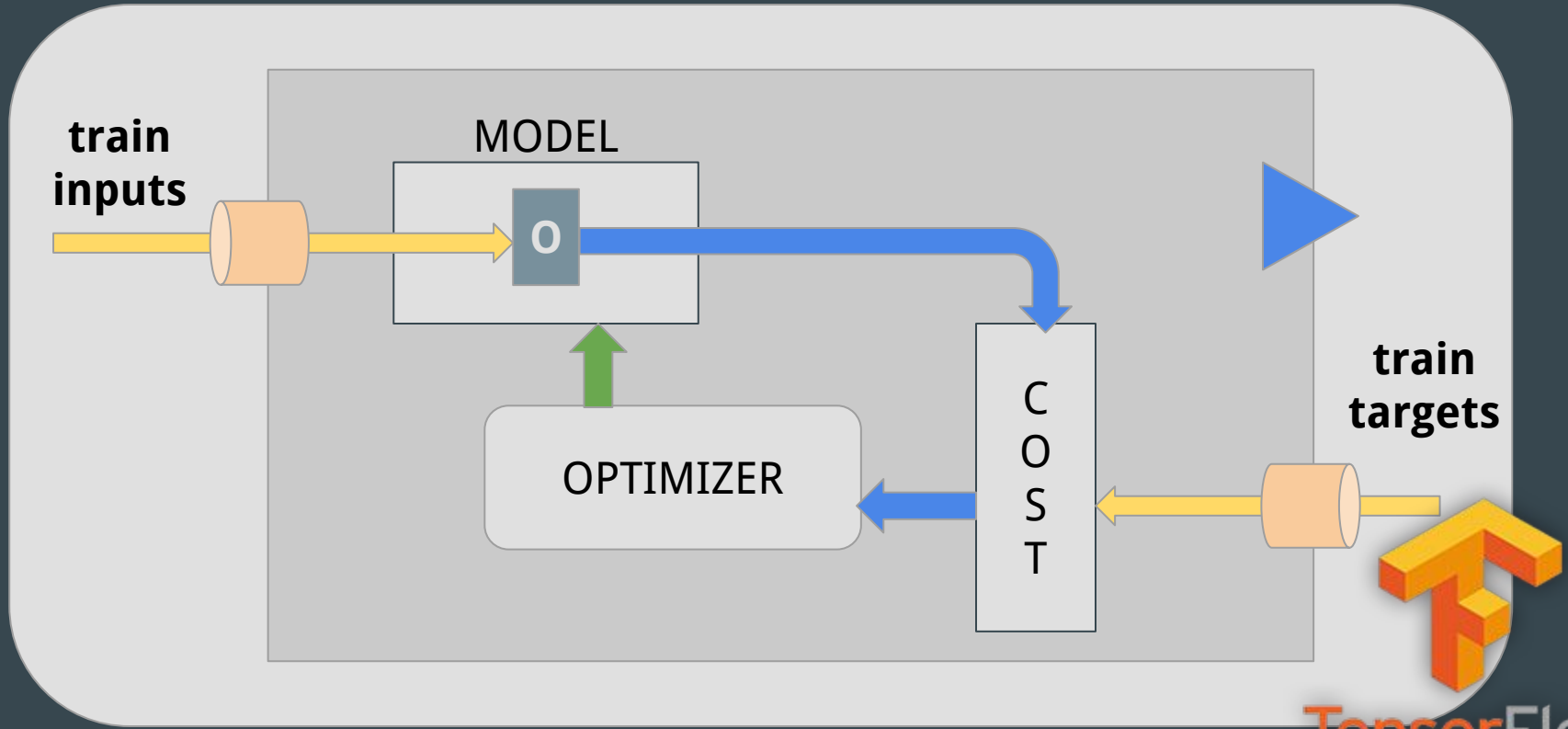
TensorFlow for Regression: learning how to sum

```
from helper import get_data, split_data

# DATA
inputs, targets = get_data(max_int=10, size=10000)

# split train and test data
train_inputs, test_inputs, train_targets, test_targets =
split_data(inputs, targets)
```

TensorFlow for Regression: learning how to sum



TensorFlow for Regression: learning how to sum

```
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())

    for epoch in range(epochs):
        sess.run(optimizer, feed_dict={
                        x: train_inputs,
                        y: train_targets
                        })
```

```
Testing Accuracy: 0.9568796753883362

The sum of 5 plus 7 is 11.991448402404785

The weights are: [[ 0.88418758]
 [ 0.8903569 ]]
and the bias is: [ 1.33801162]
```

Classification

cat

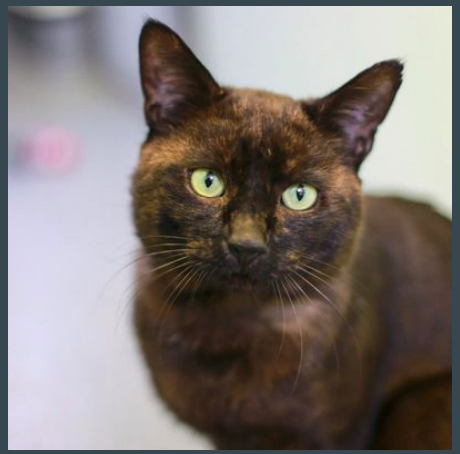
non-cat

TensorFlow

[0, 1]

[1, 0]

TensorFlow



MODEL

[0.175,

0.825]

TensorFlow

MODEL

[0.457,

0.543]

TensorFlow

MODEL

[0.457,
+ 0.543]
1.000

TensorFlow

TensorFlow for Classification

- Mission: learn if the sum of two numbers is higher than 10.

$$\text{if } (x_1 + x_2 > 10) \text{ then } y = [0; 1]$$

$$\text{else } y = [1; 0]$$

TensorFlow for Classification

- Mission: learn if the sum of two numbers is higher than 10.

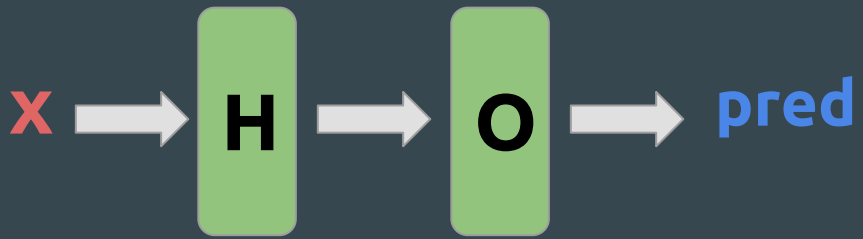
$$x_1 \;??\; x_2 = y$$

TensorFlow for Classification

- Mission: learn if the sum of two numbers is higher than 10

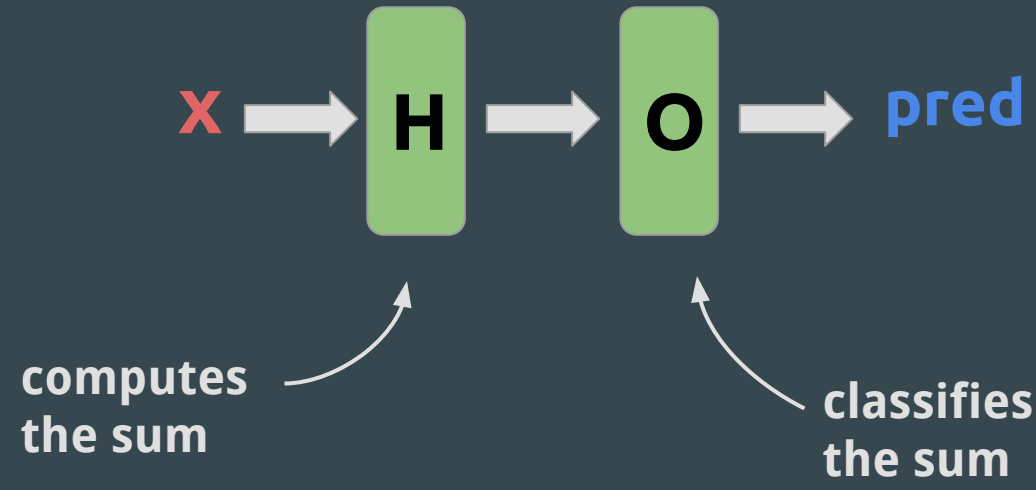
$$x_1 \;??\; x_2 = y$$

- More complexity: we add a new layer



Neural Networks: intuition

First layers extract the more basic features, while the next ones will work from this information.



TensorFlow

Neural Networks: intuition

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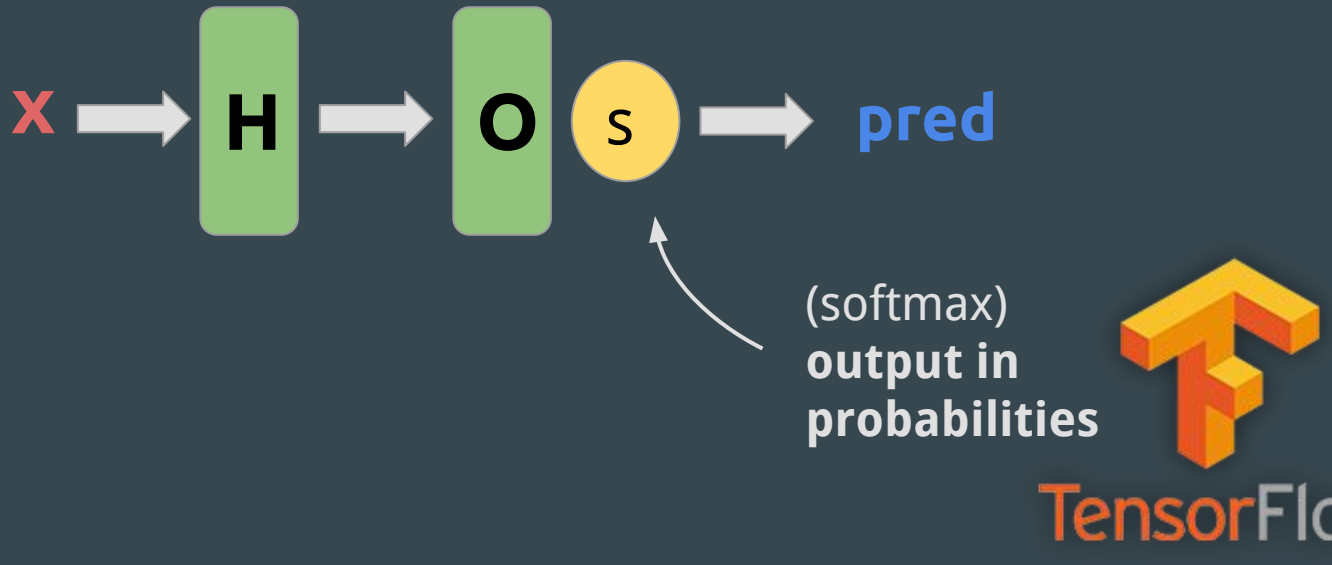

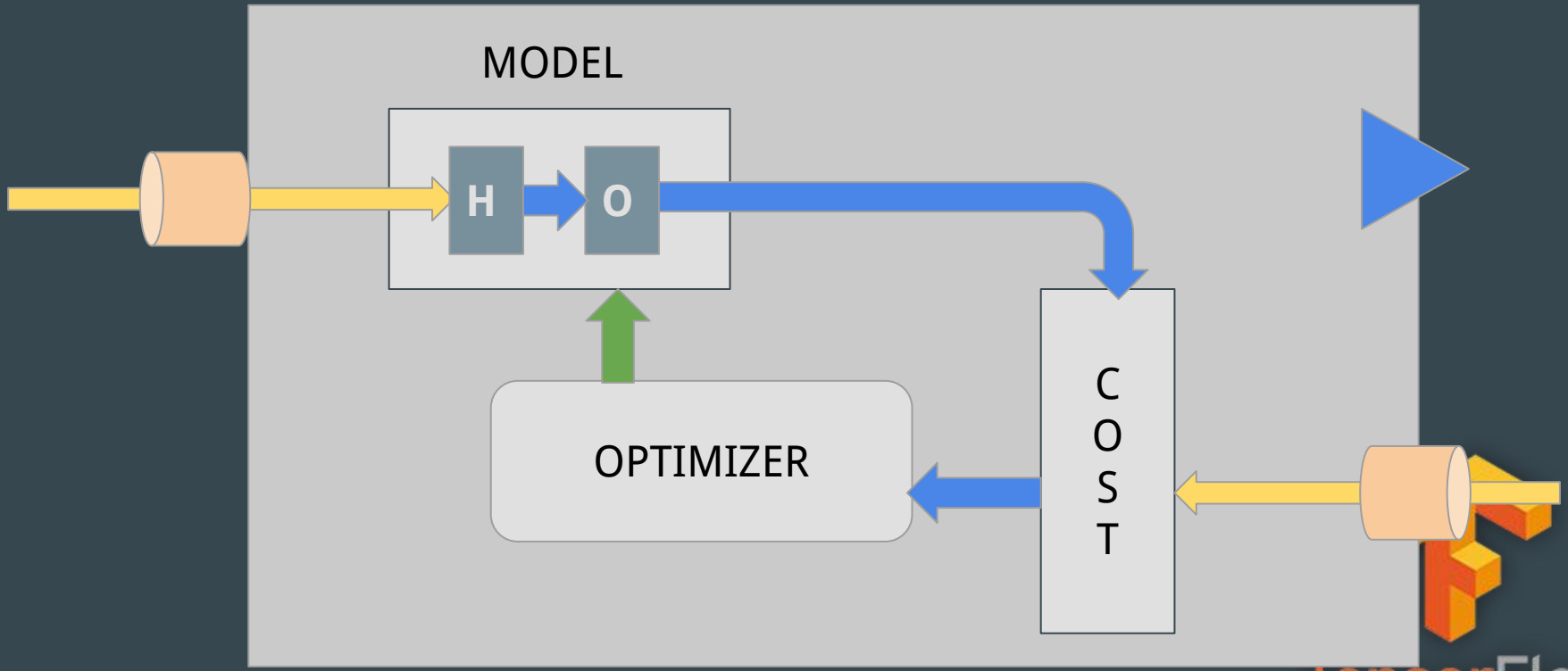
MODEL
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TensorFlow

```
Testing Accuracy: 1.0

Final test (5 + 3), (7 + 6), (10 + 10):
[[  8.93008471e-01   1.06991500e-01]
 [  1.24206737e-01   8.75793278e-01]
 [  4.71629581e-04   9.99528408e-01]]

Hidden layer weights and bias:
[[-1.64704931]
 [-1.64078069]]
[ 0.19933932]
Output layer weights and bias:
[[ 1.21974468 -1.26005733]]
[-0.2669307]
```

To know more...

Deep learning

- Neural Networks and Deep Learning - **Michael Nielsen**
- Stanford's CS231n - **Andrej Karpathy**

Tensorflow

- Tensorflow Tutorials - **Hvass Laboratories**
- Deep Learning Foundations Nanodegree - **Udacity**

To start to know more...

Basics

- Intro to Data Science - Udacity
- Intro to Machine Learning - Udacity

alesolano/mastering_tensorflow

+ A.I.

TensorFlow


Google