TensorFlow

Welcome to TensorFlow 2.0

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Machine Learning Tokyo

TensorFlow

An open source Deep Learning library

- Released by Google in 2015
- >1800 contributors worldwide

TensorFlow 2.0

- **Easier to use**
- Code styles for beginners and experts
- Alpha released in March, 2019

Topics

For beginners and experts

- Keras Sequential
- Keras Subclassing
- Built-in vs custom training loops

Under the hood

- AutoGraph and tf.function
- TF2 vs TF1

Beyond “Hello World”

- Tutorials for Deep Dream, GANs, Machine Translation

Learning more

- Book recommendations

What exactly is TensorFlow?

- And, what problems are Deep Learning libraries trying to solve?

TensorFlow

Why is Python popular for scientific computing?

Ballpark benchmarks

About how much slower is Python than C?

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- Multiplying matrices: +/- 100X
- 6 seconds vs. 10 minutes
- Running vs. flying (6 MPH and 600 MPH)

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Python is a great choice for scientific computing

- Why?

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Python is a great choice for scientific computing

- Why?

NumPy

- C performance, Python ease of use

TensorFlow is basically

NumPy

+ GPU / TPU support
+ AutoDiff
+ Utilities to help you write neural networks (layers, optimizers)

TensorFlow

- A C++ engine to accelerate code written in Python.
- **Bonus**: your program is compiled to a graph that can run on devices **without a Python interpreter** **(phones, web browsers)**

You can use TF 2.0 like NumPy

```
import tensorflow as tf # Assuming TF 2.0 is installed

a = tf.constant([[1, 2],[3, 4]])
b = tf.matmul(a, a)

print(b)
# tf.Tensor( [[ 7 10] [15 22]], shape=(2, 2), dtype=int32)

print(type(b.numpy()))
# <class 'numpy.ndarray'>
```

Exercise 1

Goals

- Install TensorFlow 2.0
- Introduce Colab
- Introduce gradient descent

Visit

- bit.ly/tf-ws1

TensorFlow

For beginners and experts

For beginners

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation='relu'),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dense(10, activation='softmax')
])
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)
model.evaluate(x_test, y_test)
```

TF 1.x

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation='softmax')
])
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)
model.evaluate(x_test, y_test)
```

TF 2.0

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation='relu'),
  tf.keras.layers.Dropout(0.2),
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])
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```

Keras and tf.keras

In my view, the **clearest Deep Learning library** that exists today.

- For fast prototyping, advanced research, and production.

keras.io = reference implementation

- `import keras`

tf.keras = **TensorFlow's implementation** (a superset, built-in to TF, no need to install Keras separately)

- `from tensorflow import keras`

For experts

```
class MyModel(tf.keras.Model):
  def __init__(self, num_classes=10):
    super(MyModel, self).__init__(name='my_model')
    self.dense_1 = layers.Dense(32, activation='relu')
    self.dense_2 = layers.Dense(num_classes, activation='sigmoid')

  def call(self, inputs):
    # Define your forward pass here,
    x = self.dense_1(inputs)
    return self.dense_2(x)
```

TensorFlow

What’s the difference?

Symbolic vs Imperative APIs

Symbolic (Keras Sequential)

- Your model is a graph of layers
- Any graph you compile will run
- **TensorFlow helps you debug** by catching errors at **compile time**

Symbolic vs Imperative APIs

Symbolic (Keras Sequential)

- Your model is a graph of layers
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- **TensorFlow helps you debug** by catching errors at **compile time**

Imperative (Keras Subclassing)

- Your model is Python bytecode
- Complete flexibility and control
- Harder to debug / **harder to maintain**

Use a built-in training loop...

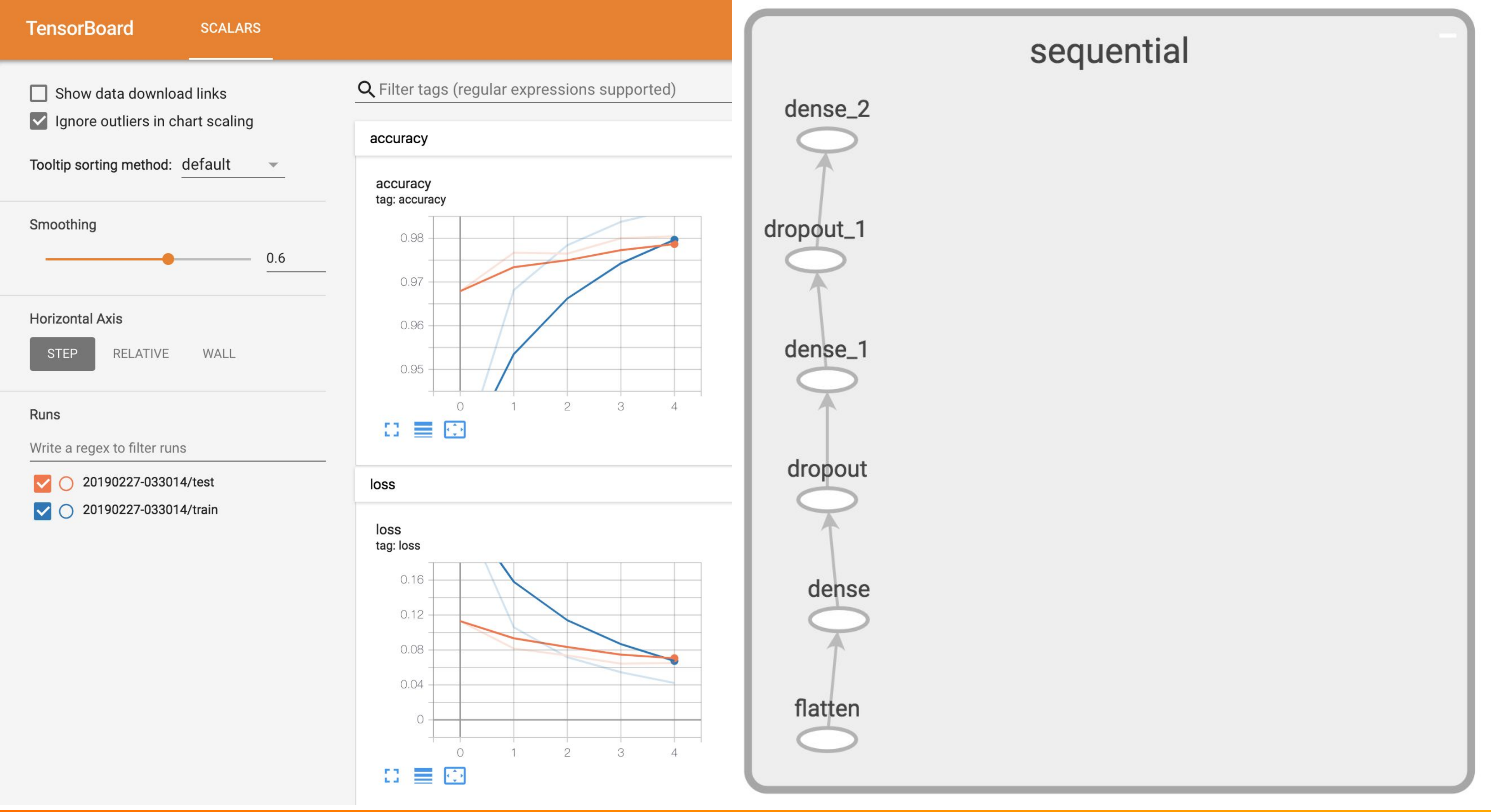
```
model.fit(x_train, y_train, epochs=5)
```

Or define your own

```
model = MyModel()

with tf.GradientTape() as tape:
  logits = model(images)
  loss_value = loss(logits, labels)

grads = tape.gradient(loss_value, model.trainable_variables)
optimizer.apply_gradients(zip(grads, model.trainable_variables))
```

TensorBoard

```
tb_callback = tf.keras.callbacks.TensorBoard(log_dir=log_dir)

model.fit(
    x_train, y_train, epochs=5,
    validation_data=[x_test, y_test],
    callbacks=[tb_callback])
```



TensorBoard
SCALARS
Show data download links
Ignore outliers in chart scaling
Tooltip sorting method: default
Smoothing
0.6
Horizontal Axis
STEP
RELATIVE
WALL
Runs
Write a regex to filter runs
20190227-033014/test
20190227-033014/train
Filter tags (regular expressions supported)
accuracy
accuracy
tag: accuracy
0.98
0.97
0.96
0.95
0
1
2
3
4
loss
loss
tag: loss
0.16
0.12
0.08
0.04
0
0
1
2
3
4
sequential
dense_2
dropout_1
dense_1
dropout
dense
flatten

Beyond Hello World

A few of my favorites

- Machine Translation
- Image Captioning (incidentally, the decoder is similar!)
- DCGan and Pix2Pix

The docs are code

Tutorials on tf.org/alpha are

- Backed by a Jupyter Notebook
- Can be run directly in Colab

They automatically

- Install the right TensorFlow version
- Download a dataset
- Train a model
- Show you the result

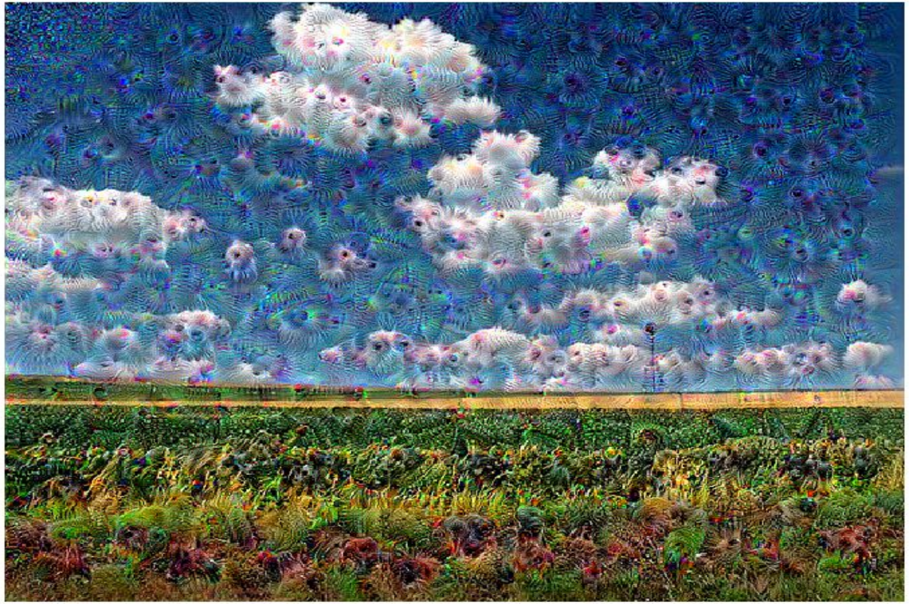
TensorFlow > Learn > TensorFlow Core > TF 2.0 Alpha

Image Captioning with Attention

Run in Google Colab | View source on GitHub

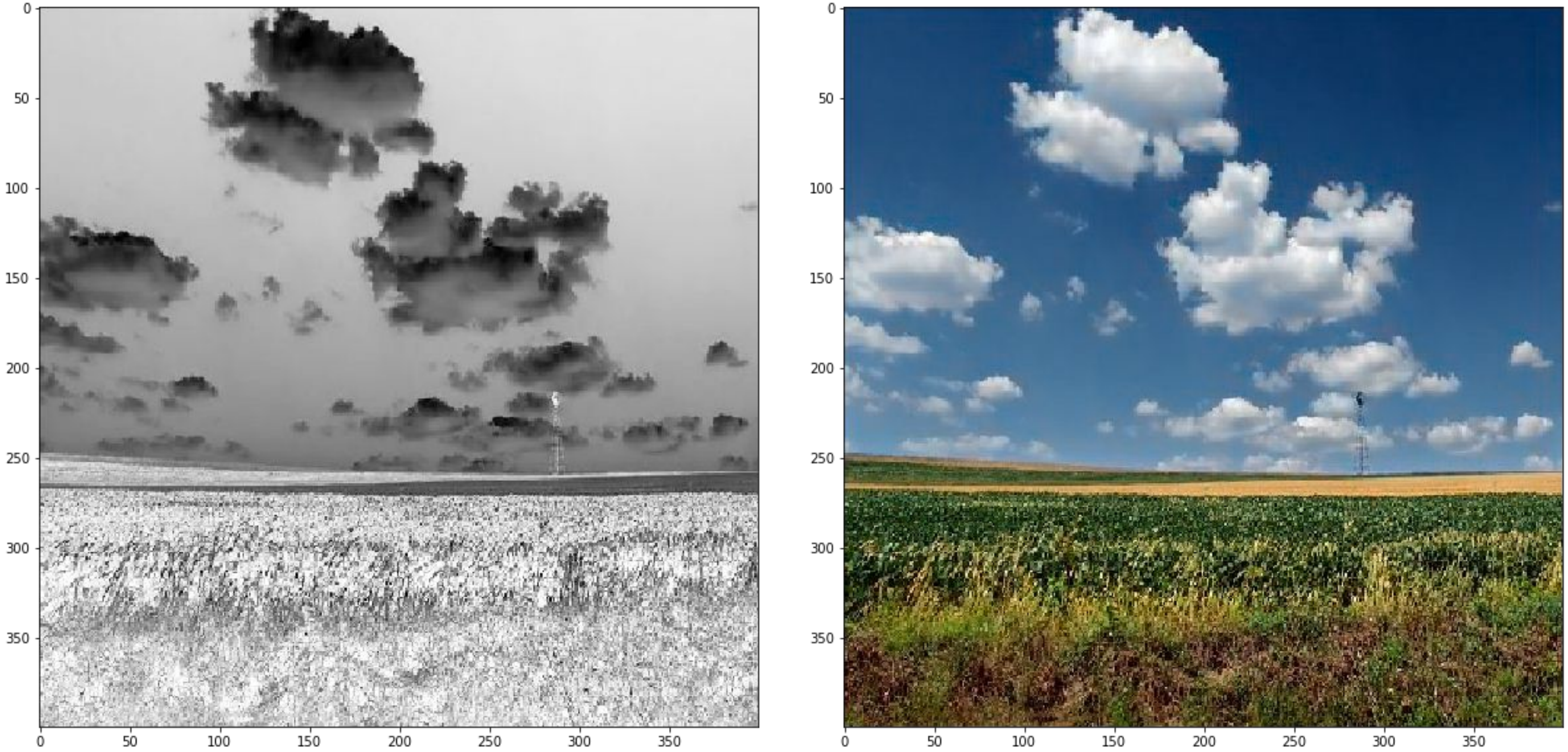
Given an image like the below, our goal is to generate a caption, such as "a surfer riding on a wave".

tensorflow.org/alpha/tutorials/text/image_captioning



https://github.com/random-forests/applied-dl/blob/master/examples/9-deep-dream-minimal.ipynb

Code walkthrough



https://github.com/random-forests/applied-dl/blob/master/examples/9-image-colorization.ipynb

Is anyone bilingual? Trilingual?

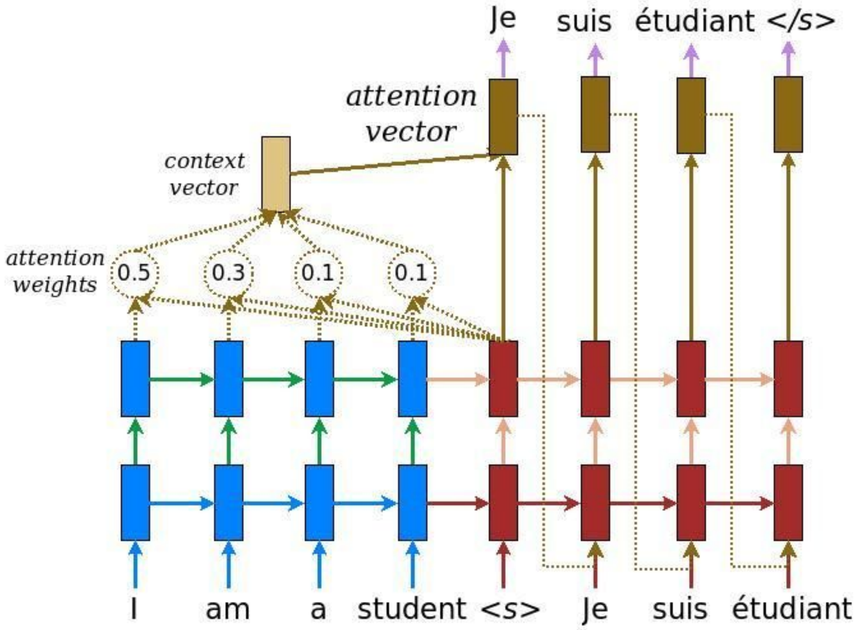
When translating, do you...

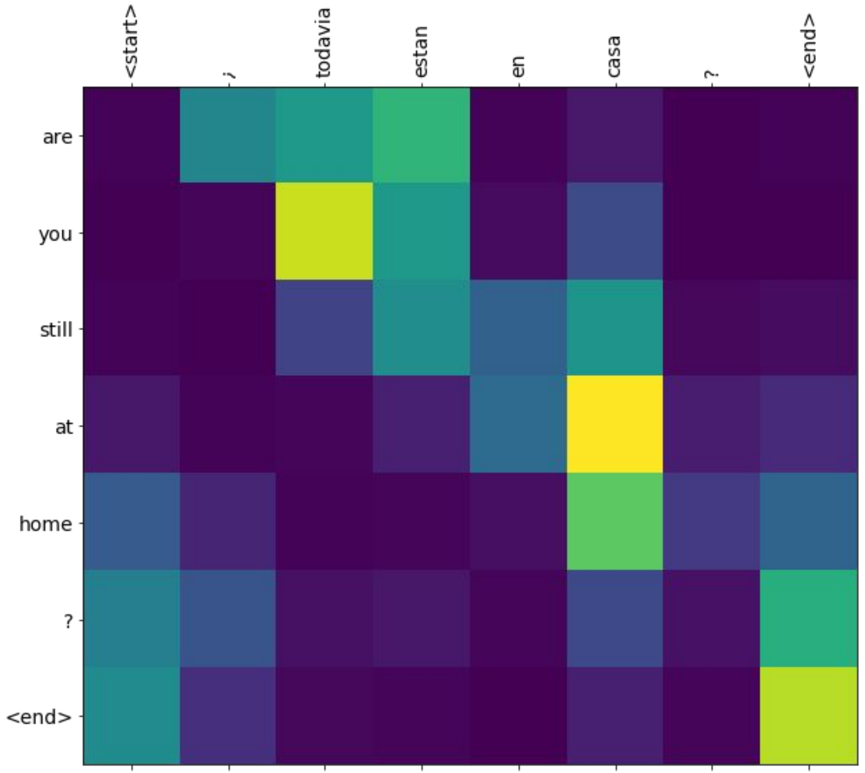
- Go directly from source -> target
- Or, go from source -> **intermediate representation** -> target.

Machine translation tutorials

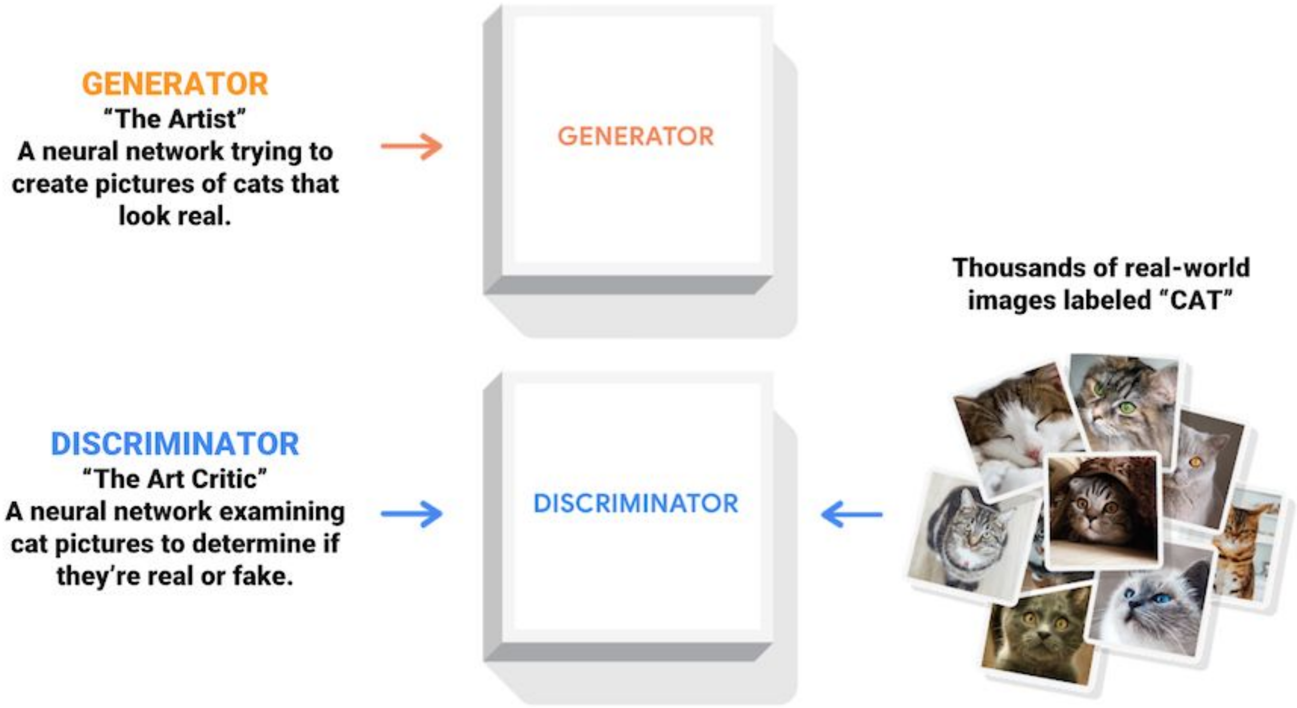
- Hello world (seq2seq), trains in about a minute.
- Neural Machine Translation with Attention
- Transformer

P.S., isn't 2019 cool? It's **amazing** this is possible.

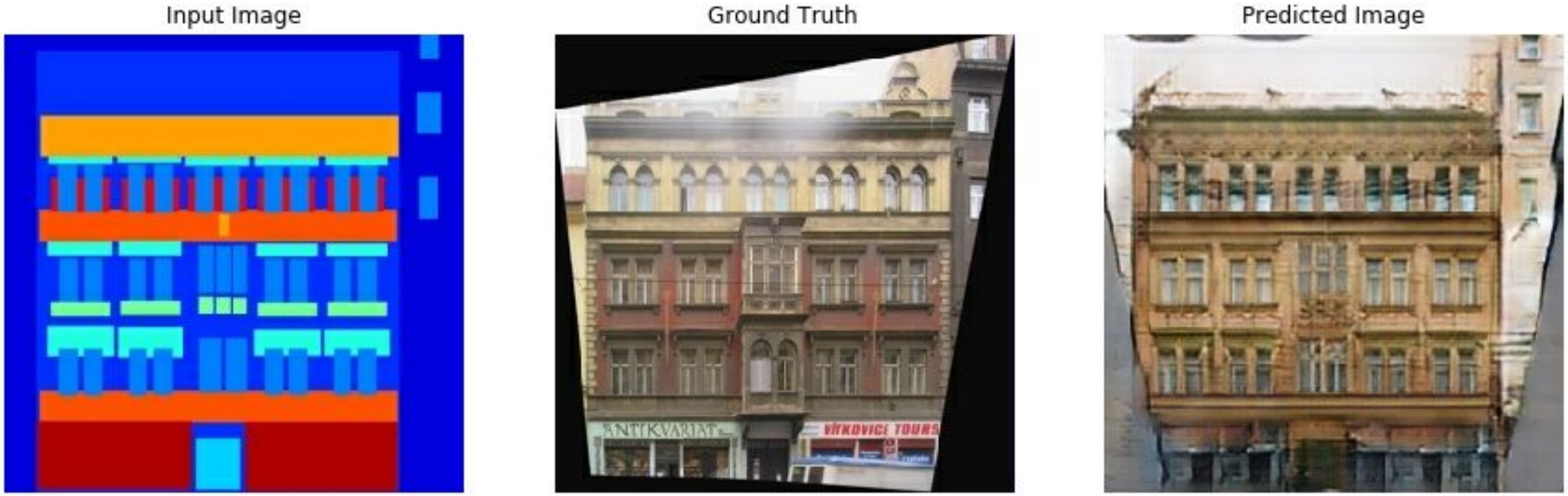




https://www.tensorflow.org/alpha/tutorials/sequences/nmt_with_attention



https://www.tensorflow.org/alpha/tutorials/generative/dcgan



https://www.tensorflow.org/alpha/tutorials/generative/pix2pix

```
Prediction Caption: the person is riding a surfboard in the ocean <end>
```

https://www.tensorflow.org/alpha/tutorials/sequences/image_captioning

Under the hood

Let’s make this faster

```
lstm_cell = tf.keras.layers.LSTMCell(10)



def fn(input, state):
  return lstm_cell(input, state)

input = tf.zeros([10, 10]); state = [tf.zeros([10, 10])] * 2
lstm_cell(input, state); fn(input, state) # warm up

# benchmark
timeit.timeit(lambda: lstm_cell(input, state), number=10) # 0.03
```

Let’s make this faster

```
lstm_cell = tf.keras.layers.LSTMCell(10)

@tf.function
def fn(input, state):
  return lstm_cell(input, state)

input = tf.zeros([10, 10]); state = [tf.zeros([10, 10])] * 2
lstm_cell(input, state); fn(input, state) # warm up

# benchmark
timeit.timeit(lambda: lstm_cell(input, state), number=10) # 0.03
timeit.timeit(lambda: fn(input, state), number=10) # 0.004
```

AutoGraph makes this possible

```
@tf.function
def f(x):
  while tf.reduce_sum(x) > 1:
    x = tf.tanh(x)
  return x

# you never need to run this (unless curious)
print(tf.autograph.to_code(f))
```

Generated code

```python
def tf__f(x):
  def loop_test(x_1):
    with ag__.function_scope('loop_test'):
      return ag__.gt(tf.reduce_sum(x_1), 1)
  def loop_body(x_1):
    with ag__.function_scope('loop_body'):
      with ag__.utils.control_dependency_on_returns(tf.print(x_1)):
        tf_1, x = ag__.utils.alias_tensors(tf, x_1)
        x = tf_1.tanh(x)
        return x,
  x = ag__.while_stmt(loop_test, loop_body, (x,), (tf,))
  return x
```

Going big: tf.distribute.Strategy

```
model = tf.keras.models.Sequential([
    tf.keras.layers.Dense(64, input_shape=[10]),
    tf.keras.layers.Dense(64, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')])

model.compile(optimizer='adam',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

Going big: Multi-GPU

```
strategy = tf.distribute.MirroredStrategy()

with strategy.scope():
  model = tf.keras.models.Sequential([
      tf.keras.layers.Dense(64, input_shape=[10]),
      tf.keras.layers.Dense(64, activation='relu'),
      tf.keras.layers.Dense(10, activation='softmax')])

  model.compile(optimizer='adam',
                loss='categorical_crossentropy',
                metrics=['accuracy'])
```

What’s different between TF1 and TF2?

Removed

- session.run
- tf.control_dependencies
- tf.global_variables_initializer
- tf.cond, tf.while_loop

Added

- tf.function, AutoGraph

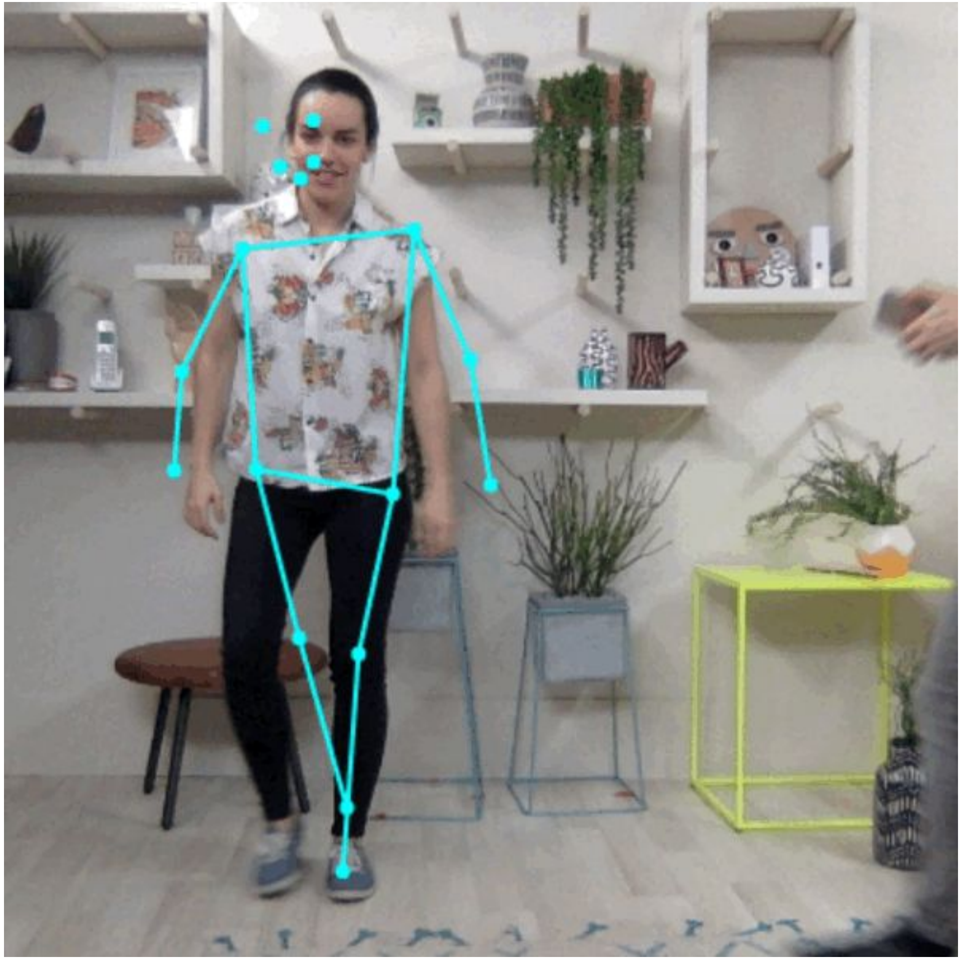
TensorFlow

TensorFlow.js

Demo #1

PoseNet

PoseNet



bit.ly/pose-net

Demo #2

BodyPix

BodyPix

bit.ly/body-pix

TensorFlow

Learning more

Learn more

Tutorials and guides

- tensorflow.org/alpha

Books

- Deep Learning with Python
- Hands-On Machine Learning with Scikit-Learn and TensorFlow (version 2.0 is almost ready)

Courses

- Intro to Deep Learning (MIT)
- Convolutional Neural Networks for Visual Recognition (Stanford)

TensorFlow

tf.thanks!

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