installing on personal machine:

1. conda create -n tensorflow1.10 # create new vm in conda
   1.1. Proceed — 'Yes'
2. conda activate tensorflow1.10
3. pip3 install tensorflow jupyter matplotlib
4. jupyter notebook

Workshop 5

COMP90051 Machine Learning

Semester 2, 2018

Learning Outcomes

At the end of this workshop you should be able to:

1. explain the fundamental characteristics of the TensorFlow computation model

2. implement logistic regression using low-level TensorFlow APIs (Worksheet 5)

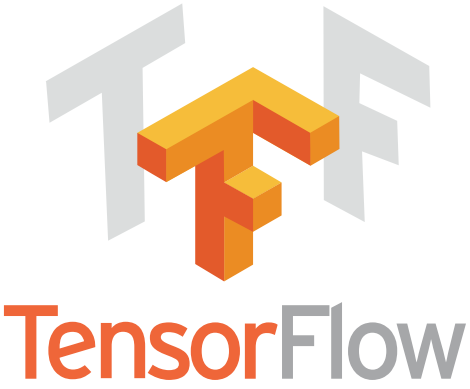
Compare w/ week 3 implementation using Numpy

What is TensorFlow?

"TensorFlow™ is an open source software library for high performance numerical computation."

– www.tensorflow.org

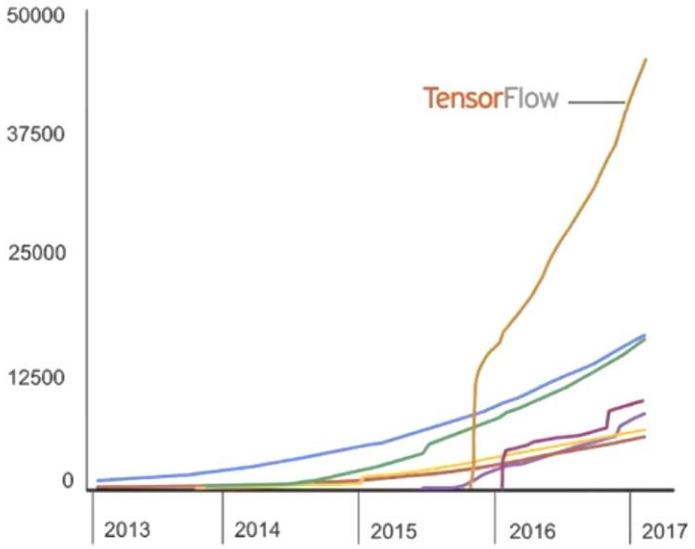
- Project started internally at Google Brain
- Open-sourced under the Apache 2.0 License in Nov 2015
- Runs on CPUs, GPUs, TPUs and can run in parallel



Why TensorFlow?

implement novel architecture

- Large community of users: easy to get help
- Strikes a good balance between flexibility and scalability



Framework	GitHub Star Count
TensorFlow	44508
scikit-learn	16191
Caffe	15690
CNTK	9383
MXNet	7896
Torch	6285
Theano	5568

(MS)
(Apache)
very scalable, but not flexible.

Source: Jiang Jun, GDG-Shanhai TensorFlow Dev Summit 2017

TensorFlow Basics

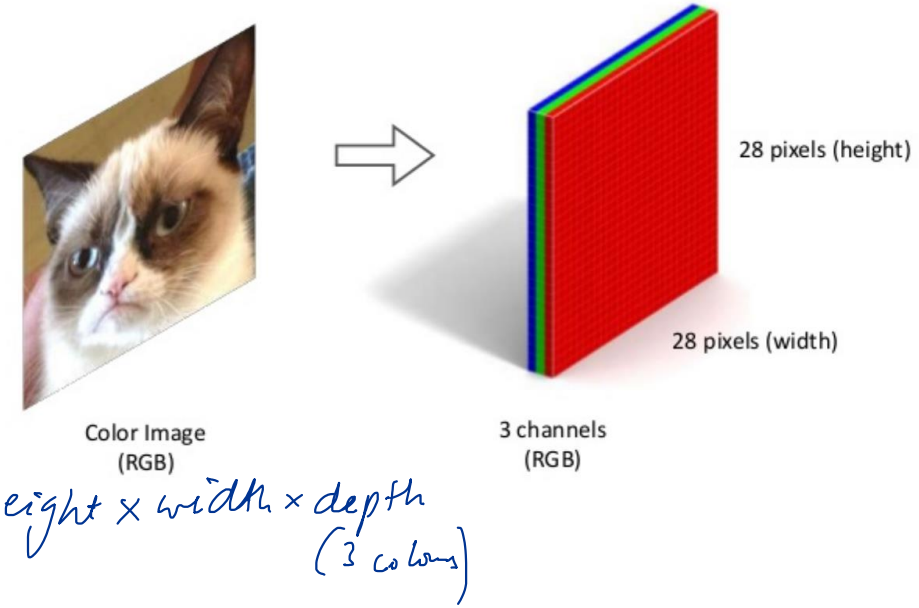
What's a **tensor**?

- For computer scientists:

  "a multidimensional array"

- [Note: richer meaning in maths/physics]
- Examples:
  - 0-d tensor: a scalar
  - 1-d tensor: a vector
  - 2-d tensor: a matrix
  - 3-d tensor
  - …

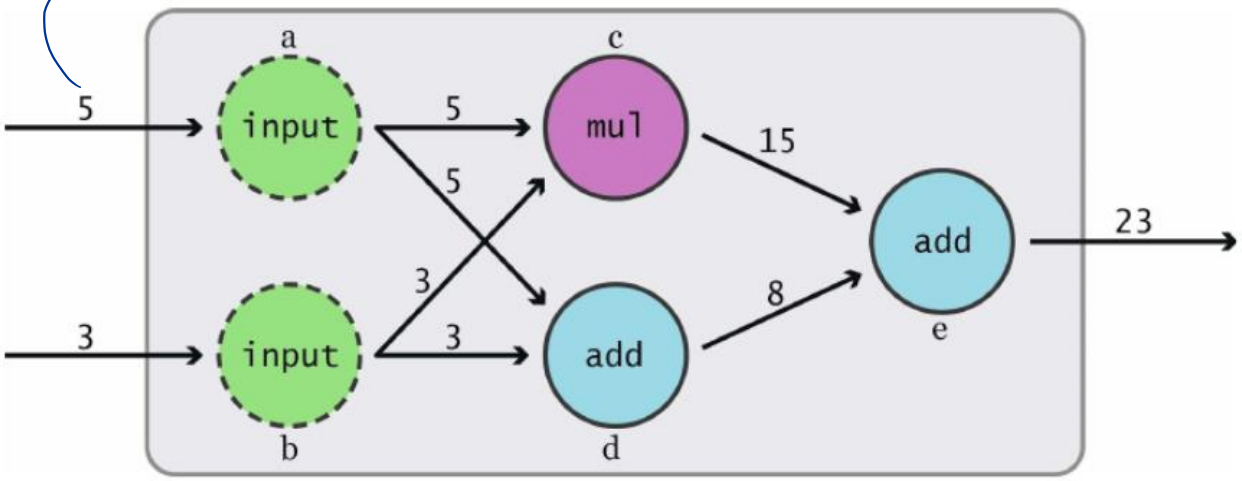
(colour image)



Data flow graphs

- Computation model adopted by TensorFlow
- A directed graph where
  - **Nodes** are operators/variables/constants (functions or inputs into the graph)
  - **Edges** are tensors

scalars in this example

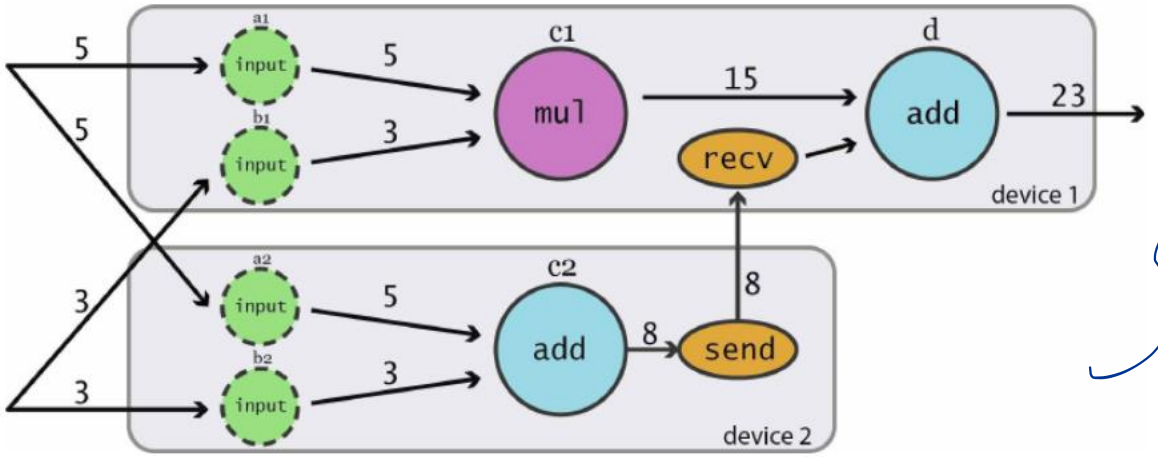


Source: Abrahams et al. *TensorFlow For Machine Intelligence.* 2016

Data flow graphs

naturally corresponds to N.N. notation/diagrams

- Advantages:
  - Connection to NNs: also represented as directed graphs
  - Automatic differentiation: break up computation into small, differentiable parts
  - Distributed computation: can split across CPUs, GPUs, TPUs



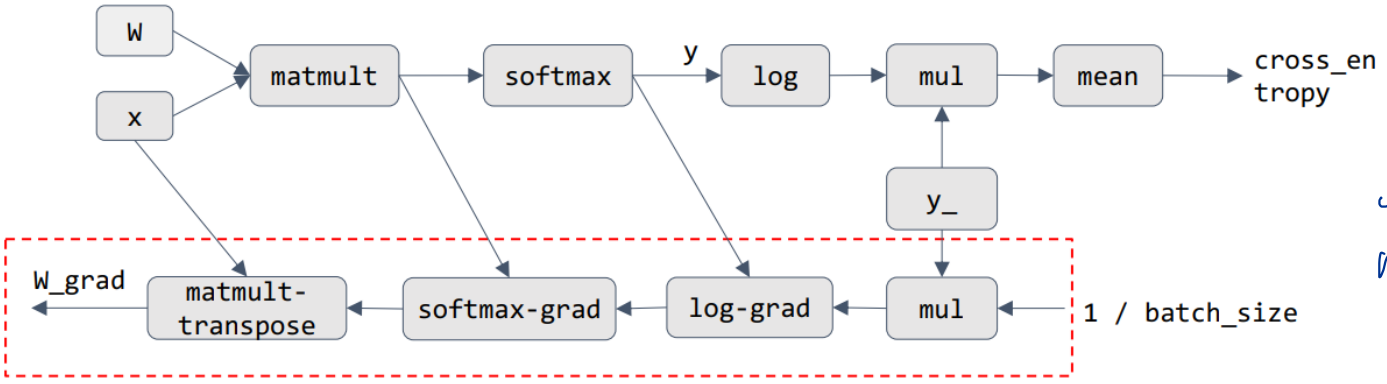
Source: Abrahams et al. *TensorFlow For Machine Intelligence.* 2016

for big NN, good way to parallelize things

Automatic differentiation

- Given a computation graph f, can automatically generate a *new* computation graph that computes ∇f
- How? Traverse the graph in reverse, replacing each node op by the corresponding gradient op
- **Automatic so don't need to worry about it!**

it's all coded in C++ behind the scenes so is very efficient



Source: University of Washington CSE599W Spring 2018 Lecture slides

Basics of graph building

- Create tensors for data input using `tf.placeholder()` (input node)
- Create tensors for parameters (to be optimised) using `tf.get_variable()` or `tf.Variable()` i.e. weights / bias
- Build up operations on tensors:
  - Simple: e.g. `a + b`, `tf.matmul(a,b)`
  - Composite: e.g. `tf.layers.dense(...)`
    - * Convolution layers.

Then use a session to execute operations on the graph

Might change with eager mode

Session, run, initialization

- Need a Session to compute outputs of the graph. Can call `tf.Session()` to create one.
- Once you've got a session, use the `run()` method to perform computations:
  - A `feed_dict` is required for placeholders
  - Only runs subgraphs that lead to outputs you've requested
  - Can get multiple outputs at once
- If you've defined Variables you need to initialise them. Can use:
  - `sess.run(tf.global_variables_initializer())`

↳ returns tensors from the graph

A simple example

constant tensors, remain in memory.

```
import tensorflow as tf
a = tf.constant(3)
b = tf.constant(5)
c = tf.add(a, b)
with tf.Session() as sess:
   print(sess.run(c))
```

tensor

Operation doesn't run at define time—just sets up the graph

starts a session.

Session allows us to use the defined graph

Requesting the value of variable c

return to Python session.

High-level APIs on top of TensorFlow

- Keras [tf.keras]
  - High-level API for ANNs
  - Now part of TensorFlow core (officially)
  - Supports other (non-TF) backends

- Sonnet
  - Another high-level API for ANNs
  - Supported by DeepMind (Google) → swith researchers on DeepMind

- tf.Estimator [tf.estimator.Estimator]
  - API for training, evaluation, prediction
  - Recommended to replace skflow (offered a similar interface to scikit-learn, now deprecated) → baby Tensorflow

Resources

- Official tutorials: https://www.tensorflow.org/tutorials/
- Official API docs: https://www.tensorflow.org/api_docs/
- Stanford CS20 course website: http://web.stanford.edu/class/cs20si/syllabus.html
- Books:
  - Aurélien Géron. *Hands-On Machine Learning with Scikit-Learn and TensorFlow.* (2017)
  - Bharath Ramsundar and Reza Bosagh Zadeh. *TensorFlow for Deep Learning: From Linear Regression to Reinforcement Learning.* (2018)

TensorFlow on the lab machines

- Open *Start* → *Anaconda3 (64-bit)* → *Anaconda Prompt*
- In the prompt, run the following commands:

```
> cd "C:\Users\%USERNAME%\Downloads"
> mkdir workshop05
> cd workshop05
> pip install -t . tensorflow "protobuf<3.6.1"
> jupyter notebook
```

- Copy Worksheet 5 into the `workshop05` directory
- Open Worksheet 5 from within Jupyter

latest version 1.1.0
recommend install in VM.

Note: This is a workaround installation method due to restrictions on the lab machines. On your own device, we recommend following the installation instructions at https://tensorflow.org/install/