Visualizing Dataflow Graphs of Deep Learning Models in TensorFlow

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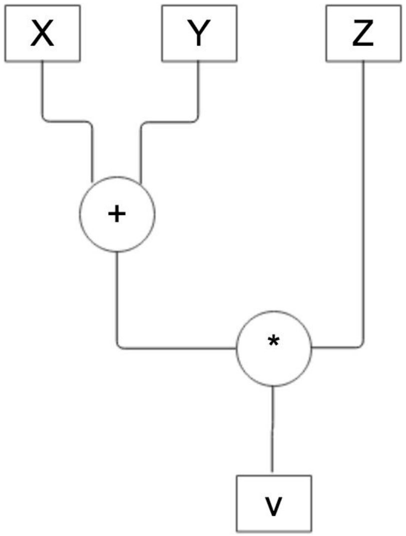
Background

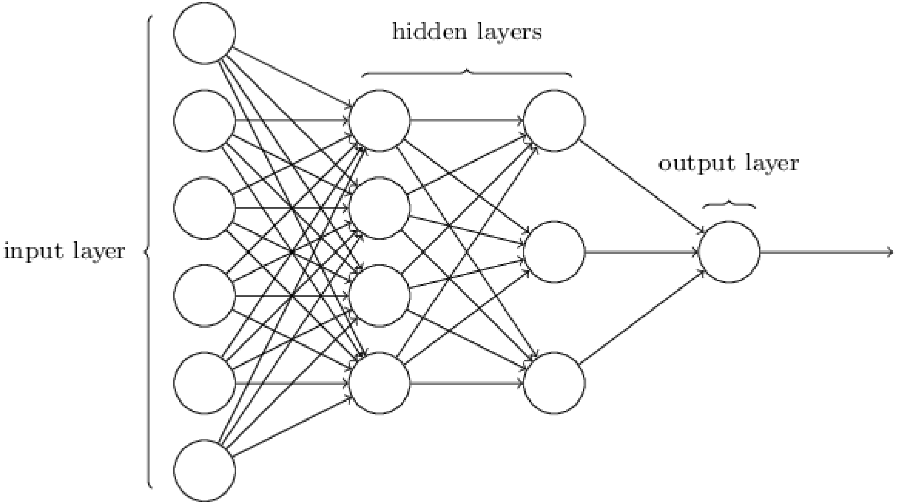
- Dataflow graphs
  - Represent data dependencies between operations
  - **Node**: a unit of computation
  - **Edges**: Data flowing in/out of computation node



V = (X+Y) * Z

Background

- Deep learning models
  - State of the art for many problems in ML
  - Can get very big!
  - Interpretability is a big issue



Artificial neural network. (2017, November 7). In *Wikipedia, The Free Encyclopedia*. Retrieved 06:32, November 13, 2017, from https://en.wikipedia.org/w/index.php?title=Artificial_neural_network&oldid=809235583

TensorFlow

- An API for building neural networks
  - Simplifies the coding process
  - Built around the idea of a dataflow graph
  - Edges are tensors
  - Nodes are mathematical operations

Goals

- Provide an intuitive overview
- Recognize similarities and differences between graph components
- Examine nested structure of a high level component
- Inspect details of low level operations
- Examine quantitative data

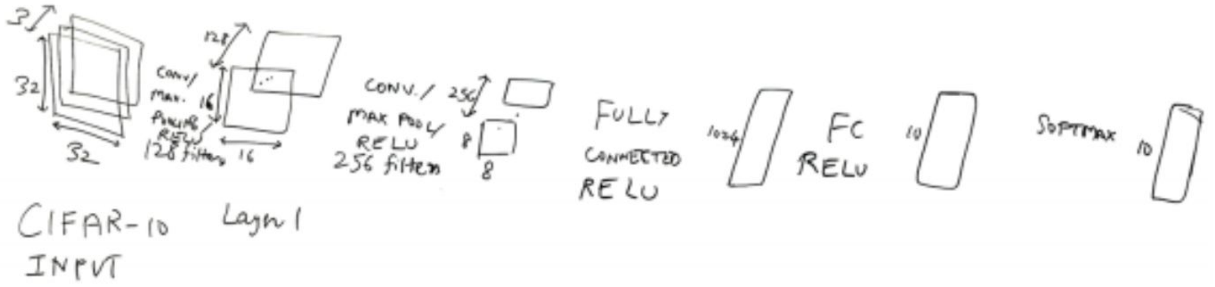
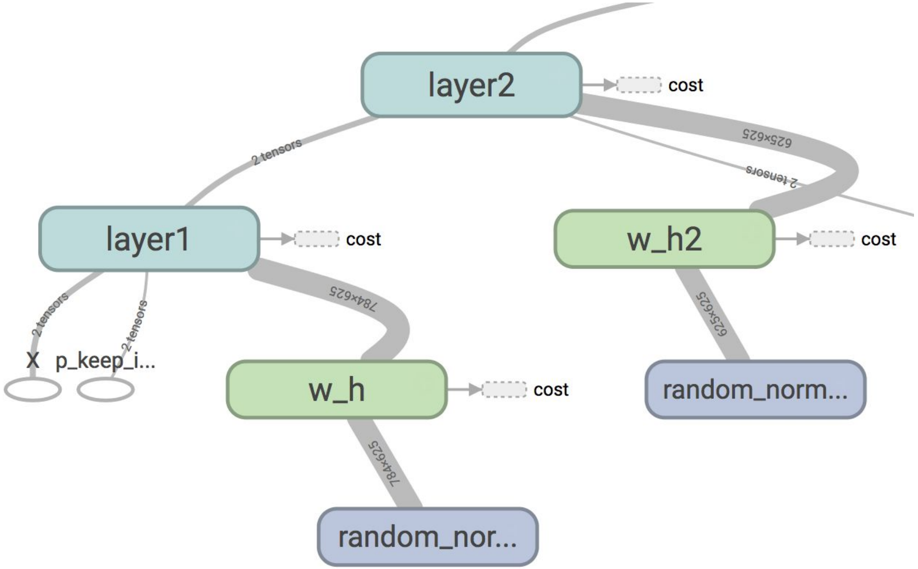


Fig 2. From Visualizing Dataflow Graphs of Deep Learning Models in TensorFlow Kanit Wongsuphasawat et al. *EEE Trans. Visualization & Comp. Graphics (Proc. VAST)*, 2018

Basic Encoding



Problem

- Standard graph layout techniques don’t work well out of the box
  - Mismatch between graph topology and semantics
  - Graph heterogeneity = Not all nodes are created equal
  - Interconnected nodes

Graph Transformations

Remove non-critical nodes

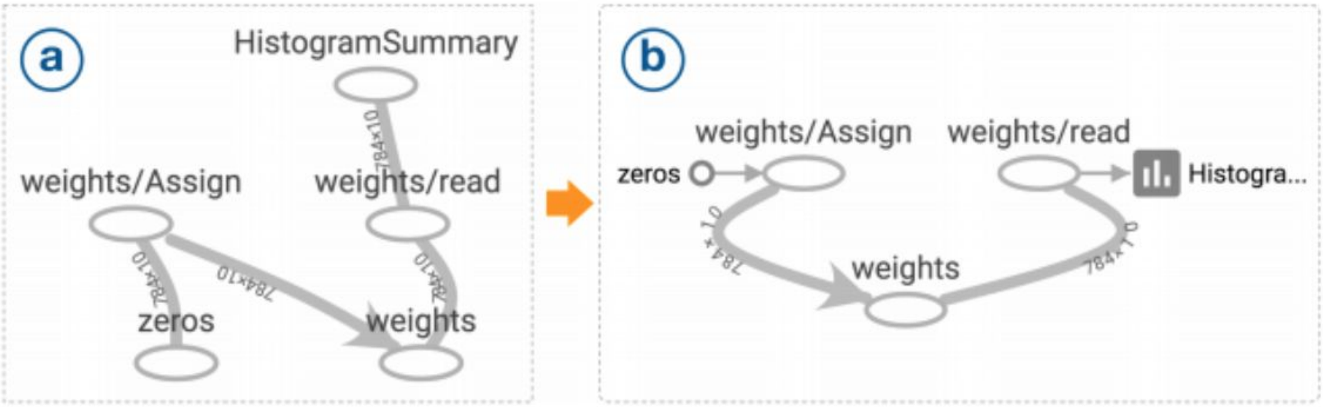


Fig 3. From Visualizing Dataflow Graphs of Deep Learning Models in TensorFlow Kanit Wongsuphasawat et al. *EEE Trans. Visualization & Comp. Graphics (Proc. VAST)*, 2018

Graph Transformations

- Build a hierarchically clustered graph
  - Group operations based on namespaces
  - Bundle edges between groups

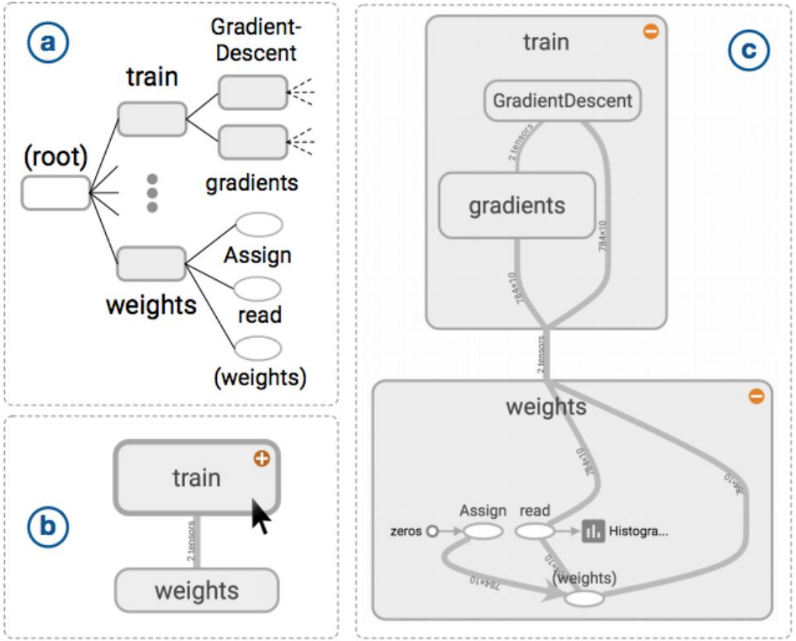
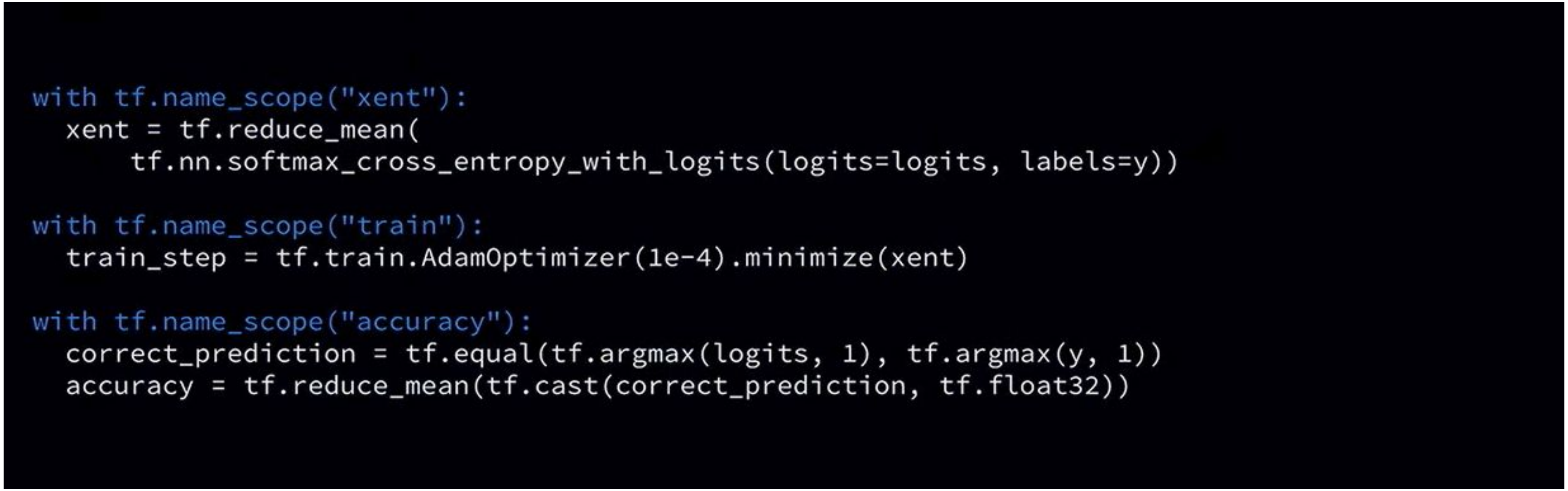


Fig 4. From Visualizing Dataflow Graphs of Deep Learning Models in TensorFlow Kanit Wongsuphasawat *et al. EEE Trans. Visualization & Comp. Graphics (Proc. VAST)*, 2018

Namespaces



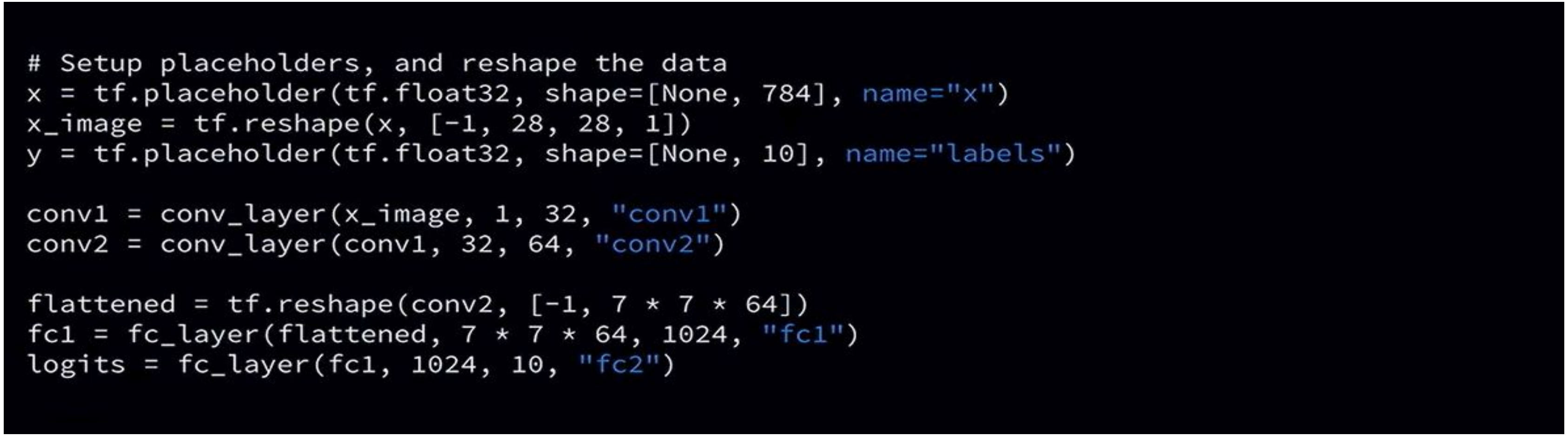
```
with tf.name_scope("xent"):
  xent = tf.reduce_mean(
      tf.nn.softmax_cross_entropy_with_logits(logits=logits, labels=y))

with tf.name_scope("train"):
  train_step = tf.train.AdamOptimizer(1e-4).minimize(xent)

with tf.name_scope("accuracy"):
  correct_prediction = tf.equal(tf.argmax(logits, 1), tf.argmax(y, 1))
  accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
```

[Google Developers]. (2017, Feb 15). Hands-on Tensorboard (TensorFlow Dev Summit 2017) [Video File]. Retrieved from https://www.youtube.com/watch?v=eBbEDRsCmv4

Namespaces



```
# Setup placeholders, and reshape the data
x = tf.placeholder(tf.float32, shape=[None, 784], name="x")
x_image = tf.reshape(x, [-1, 28, 28, 1])
y = tf.placeholder(tf.float32, shape=[None, 10], name="labels")

conv1 = conv_layer(x_image, 1, 32, "conv1")
conv2 = conv_layer(conv1, 32, 64, "conv2")

flattened = tf.reshape(conv2, [-1, 7 * 7 * 64])
fc1 = fc_layer(flattened, 7 * 7 * 64, 1024, "fc1")
logits = fc_layer(fc1, 1024, 10, "fc2")
```

[Google Developers]. (2017, Feb 15). Hands-on Tensorboard (TensorFlow Dev Summit 2017) [Video File]. Retrieved from https://www.youtube.com/watch?v=eBbEDRsCmv4

Graph Transformations

Extract Auxiliary nodes from the graph

- Many high-degree nodes turn out to be not that important
  - NoOp nodes
  - Declaring/initializing variables
  - Nodes that compute statistics
- Nodes extracted and put to the right of the whole graph
- Small proxy icons to embedded in neighbouring nodes

Graph Transformations

Deep Learning models have highly repeated structure

- Group nodes with identical subgraphs have the same color
- Finding these subgraphs is NP-hard

VAD Analysis

- **What: Data**
  - Network
- **What: Derived**
  - Cluster hierarchy
  - Edges bundled
  - Nodes removed or embedded
- **Scale:**
  - 1000s of nodes

- **How: Encode**
  - Ellipse/Rectangle marks for nodes, connection marks for links
- **Why: Tasks**
  - Make graph understandable

Demo

Critique

Positive

- Provides an intuitive overview of the dataflow graph
- Makes it easier to debug deep learning models
- Infinitely better than sketches

Negative

- No two-way editing
- Can be hard to tell quickly how the data flows through the network
- Debugging could be improved if integrated with tests
- Diff-viewer would also aid debugging