An Introduction to Machine Learning using TensorFlow

With Examples from the MNIST dataset.

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Machine Learning

What is Machine Learning?

Definition Machine Learning[1]

- 3 attributes
  - Experience E
  - Task T
  - Performance Measure P

A computer program is said to learn if its performance at tasks in T as measured by P improves with experience in E.

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It is very hard to write a program to recognize an object in an image.

- We do not know how to to perform this computation.
- A number of intuitive rules in our day-to-day decision making.

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Types of Machine Learning Problems

- Supervised Learning

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- Semi-supervised Learning
- Reinforcement Learning.

Types of Machine Learning Problems

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- Regression: The output variable is usually a real value.

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- MNIST: a database of handwritten digits. ML equivalent of fruit flies.
- Easy to understand and compare algorithms.
- Textbook Example of ML.

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- Sample: 28×28 pixels, Each pixel is a 0 or 1
- Vector size per sample: 785 ($28 \times 28 + 1$)
- First real success story in ML.

Tensorflow

Tensorflow: Framework for Numerical Computation

- One of several frameworks: Theano, Caffe, MxNet, CNTK, Keras, Torch, Spark, Flux (Julia), KNet (Julia).

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- Opensourced by Google
- Library for efficient multidimensional array processing.
- Advantages of using TF:
  - Primitives for defining functions on tensors.
  - Parallelize operations.
  - Automatic differentiation.

Tensors

What is a tensor?

- Multi-dimensional array

Tensors

What is a tensor?

- Multi-dimensional array
- A multidimensional version of a vector.

0-dimensional	scalar
1 -dimensional	vector
2-dimensional	matrix
3-dimensional	3-tensor

Example:

- Black and White image: 2D tensor (1 channel: $H \times W$)
- RGB color image: 3D tensor (3 channels: $H \times W \times 3$)

In the style of functional programming, think of a tensor as a mapping from a multidimensional array to a real valued scalar.

Computation Graphs

Workflow in TF

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- Ability to run the computation on GPUs.
- Python based: can build models using Jupyter notebooks.
- One can build wrappers around TF and call it from other languages.

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- FeedForward Network

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- Convolutional Network:
  - Assumes some kind of spatial structure in its input.
  - Inputs that are close to each other are related.
  - Sparse weight matrix.
  - Weights are shared (i.e. patterns are repeated across regions of the image.)

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- Recurrent Network:
- Used to model sequences of data. e.g. Temporal pattern like text, music etc.

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Digit Recognition Model

- Each input: 28 x 28 x 1 matrix B & W: Therefore 1 channel. RGB color input: 3 channels.
- Simple Convolutional Architecture This has two iterations of
  - Convolution
  - ReLU: Rectified Linear Unit $max(input, 0)$. Other possibilities are sigmoid, tanh.
  - MaxPool
- At the end, we have a dense layer that converts into a softmax probability output.
- Softmax function: Allows us to map a real number into multiple categories.
- One hot encoding: Allows us to model categorical data. e.g. $1 = [1\ 0\ 0]$, $2 = [0\ 1\ 0]$, $3 = [0\ 0\ 1]$