TENSOR... TENSORFLOW… AND… KERAS TOO…

Introduction to Machine Learning, Artificial Intelligence and Deep Learning

Session 08

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Agenda

- What is Tensor
- Overview of libraries
- TensorFlow
- Summary

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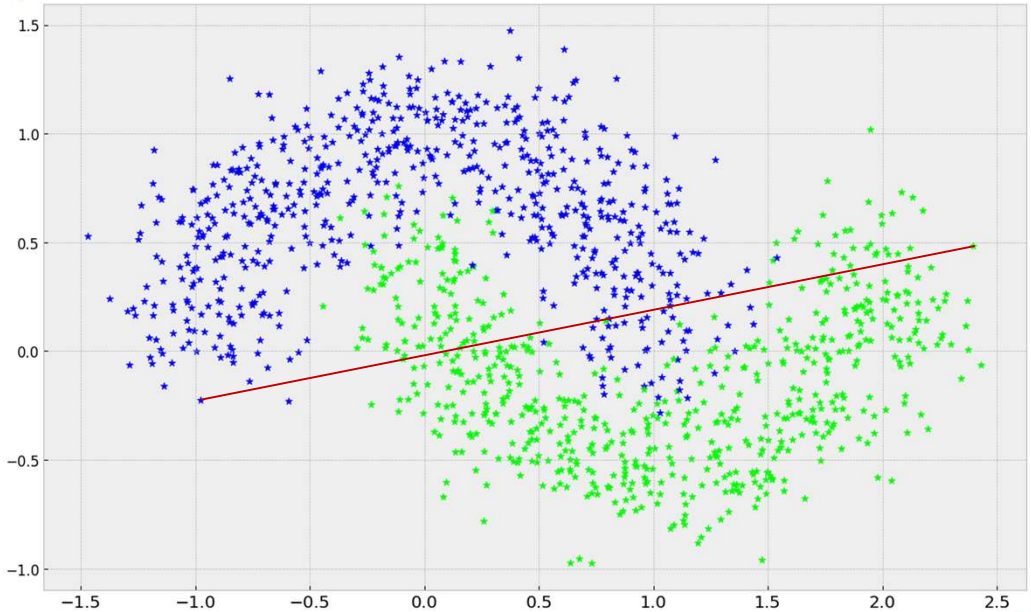
Story So far



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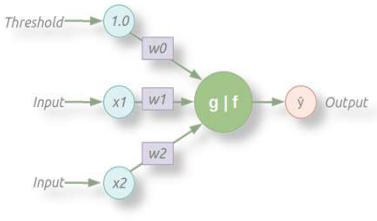
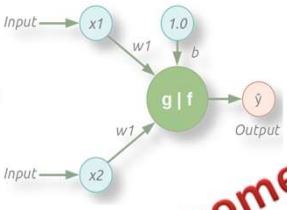
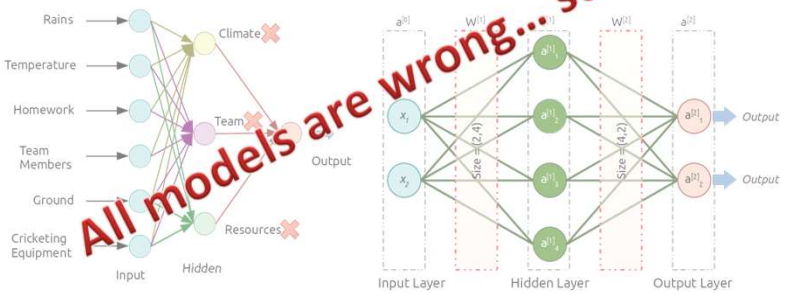
Story So far…







All models are wrong… some models are useful!

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What is Tensor…

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What is a vector????

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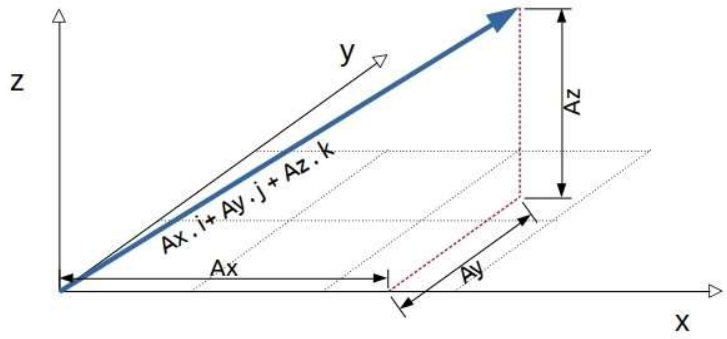
Vector – Rank 1 Tensor



Tensor of Rank 1

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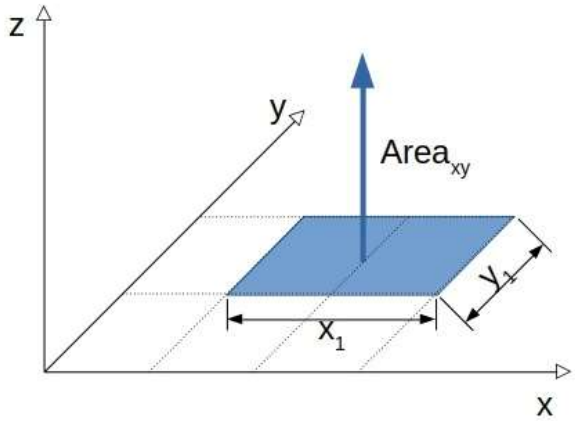
Area too can be represented as vector….



Area as a Vector

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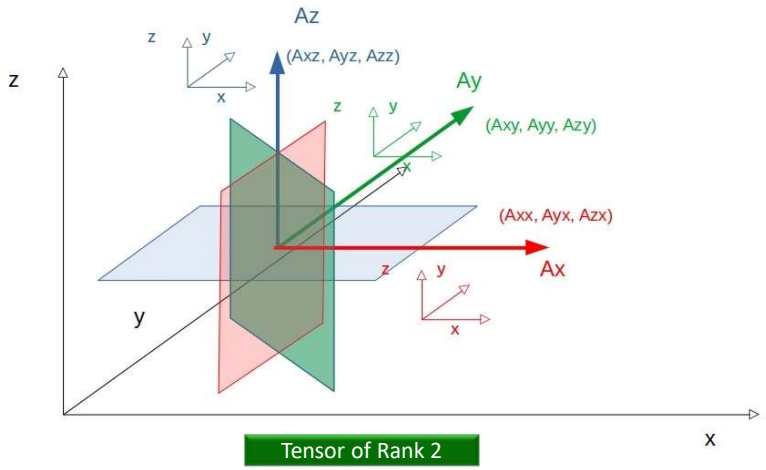
Area can have three vectors attached to it…



Tensor of Rank 2

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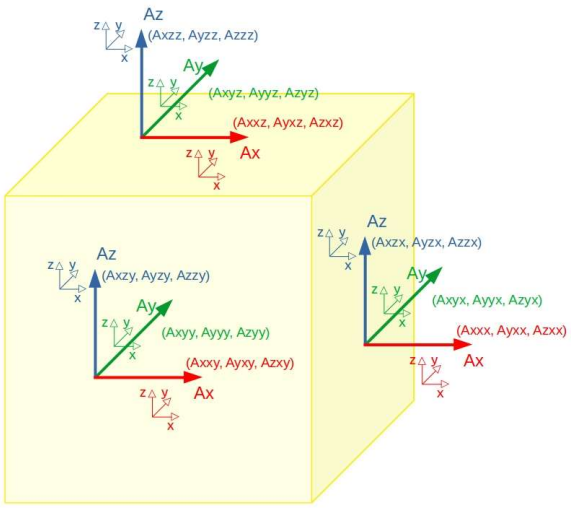
So What is Rank 3 Tensor….



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Are there more than Rank 3 Tensors….

- The rank(order) R of a tensor is independent of the number of dimensions N of the underlying space
- Consider intuitively that a tensor represents a physical entity which may be characterized by magnitude and multiple directions simultaneously (Fleisch 2012).
- Therefore, the number of simultaneous directions is denoted R and is called the rank of the tensor in question.
- A rank-0 tensor (i.e., a scalar) can be represented by N^0 = 1
- A rank-1 tensor (i.e., a vector) in N-dimensional space can be represented by N^1 = N
- A general ranked tensor by N^R numbers

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How many rank tensor can have?

Rank	Object
0	Scalar
1	Vector
2	Matrix
>=3	Tensor

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So What are Tensors

- A tensor is a multidimensional array with a uniform data type
- You can never update a tensor but create a new one
- Looks similar to Numpy Array, even behave similar way in some aspects
- A Tensor is a suitable choice on GPU
- A tensor can reside in accelerator's memory

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As a Data Scientist…

- A tensor is a type of *multidimensional array* with certain *transformation properties*
- Let's take for example velocity of some object:
  - It can be represented by three numbers, or a multidimensional array (1 x 3).
  - Value in this array depends on your system on reference.
  - In one system of reference these numbers can be [100, 0, 0].
  - In another system of reference the numbers corresponding to the velocity of this very object at this very moment can be absolutely different.
  - Let's say [60, 0, -80]
- You toss a ball in the air, how many numbers do I need to define it's velocity?
  - 1… 2… 6! Right?
    - $v_x, v_y, v_z, r_x, r_y, r_z$
  - What if I am standing outside earth?
  - Outside our galaxy…. My head is spinning already!
- It's the rules of changing representation when switching between systems of reference that make multidimensional array a tensor.

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"Tensors are fact of universe" - Lillian Liebe

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"Numpy are excellent but run on CPU only

Tensors in Tensorflow and PyTorch are attempts to make it run on GPU."

Why Tensors!

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Deep Learning Frameworks Landscape

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Deep Learning Frameworks Landscape

TensorFlow

PyTorch

Keras

Sonnet

mxnet

GLUON

DL4J

Chainer

pandas

CuPy

matplotlib

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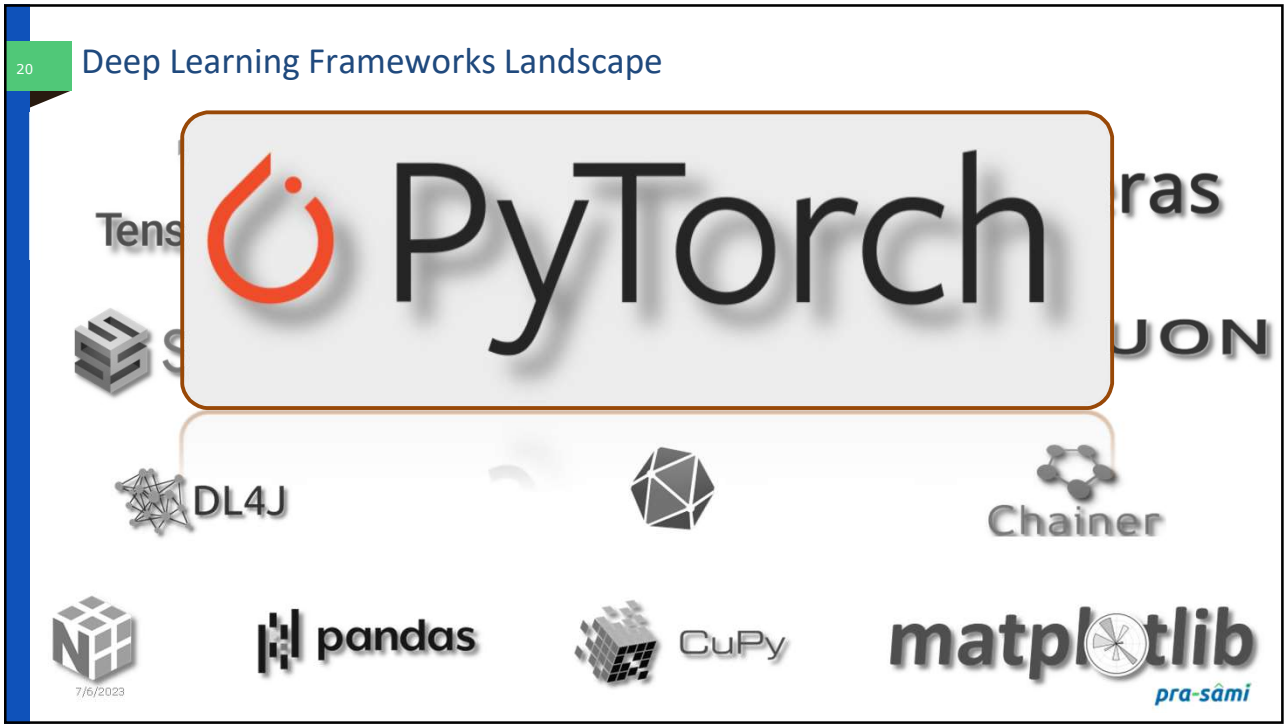
19 Deep Learning Frameworks Landscape

20 Deep Learning Frameworks Landscape



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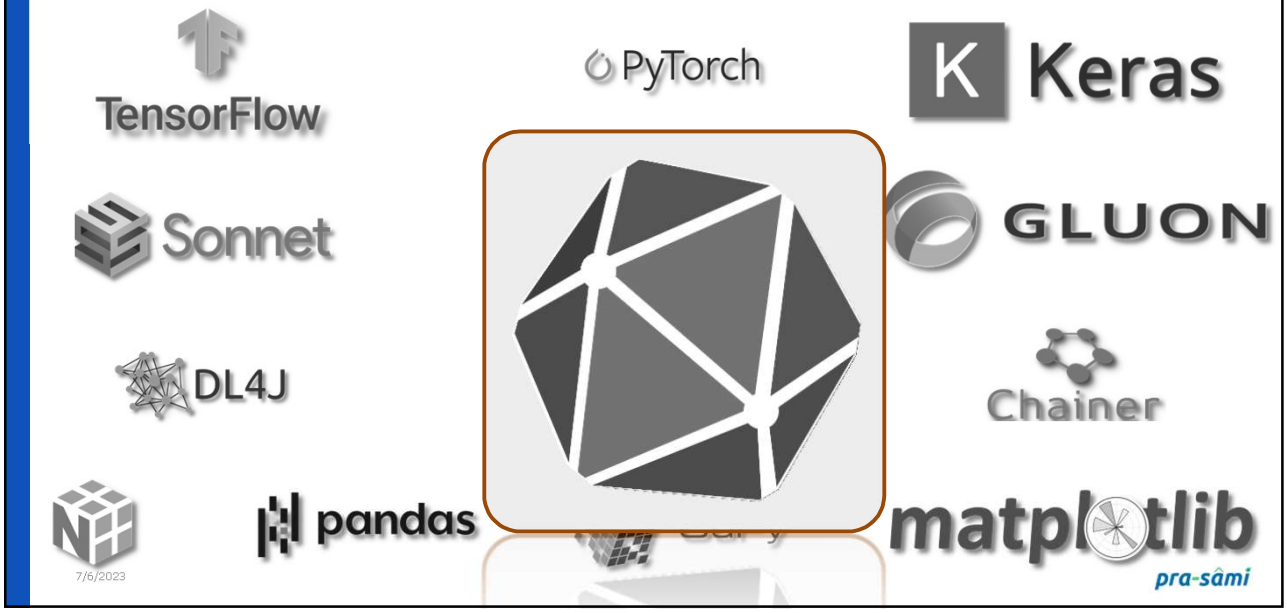
25 Deep Learning Frameworks Landscape

26 Deep Learning Frameworks Landscape



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Deep Learning Frameworks Landscape

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TensorFlow

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TensorFlow vs. Theano

- Theano was an inspiration for Tensorflow
  - A deep-learning library with python wrapper
- Theano and TensorFlow are very similar systems
- TensorFlow has better support for distributed systems though
- Development of Tensorflow is funded by Google, while Theano is an academic project.
- TensorFlow and Numpy are quite similar
  - Both are N-d array libraries!
- Numpy has Ndarray support, but doesn't offer methods to create tensor functions and automatically compute derivatives
- Numpy had no GPU support
  - CuPy for GPU support

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Formats are near similar!

Numpy	TensorFlow
a = np.zeros((2,2)); b = np.ones((2,2))	a = tf.zeros((2,2)), b = tf.ones((2,2))
np.sum(b, axis=1)	tf.reduce_sum(a,reduction_indices=[1])
a.shape	a.get_shape()
np.reshape(a, (1,4))	tf.reshape(a, (1,4))
b * 5 + 1	b * 5 + 1
np.dot(a,b)	tf.matmul(a, b)
a[0,0], a[:,0], a[0,:]	a[0,0], a[:,0], a[0,:]

31 TensorFlow requires explicit evaluation!

- a = np.zeros((2,2))
- ta = tf.zeros((2,2))
- print(a)

```
[[ 0. 0.]
 [ 0. 0.]]
```

- print(ta)

```
Tensor("zeros_1:0", shape=(2, 2), dtype=float32)
```

- print(ta.eval())

```
[[ 0. 0.]
 [ 0. 0.]]
```

TensorFlow computations define a computation graph that has no numerical value until evaluated!

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- Till version 1:
  "A Session object encapsulates the environment in which Tensor objects are evaluated"
  - TensorFlow Docs
- a = tf.constant (5.0)
  b = tf.constant (6.0)
- c = a * b
- with tf.Session() as sess:

```
print(sess.run(c))
print(c.eval())
```

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Session Object

- Till version 1 - "A Session obj… …tes the environment in which Tensor objects are evaluated" - TensorFlo…
- a = tf.constant(5.0…
  b = tf.constant(…
- c = a * b
- with tf.Sess… …s sess:
  print(… …n(c))
  print(… …)

Not available in Version 2.0!

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TensorFlow

- "TensorFlow programs are usually structured into a construction phase, that assembles a graph, and an execution phase that uses a session to execute ops in the graph." - TensorFlow docs
- All computations add nodes to global default graph (docs)
- "When you train a model you use variables to hold and update parameters. Variables are in-memory buffers containing tensors" - TensorFlow Docs.
- Variables are created and tracked via the tf.Variable class.
  - A tf.Variable represents a tensor whose value can be changed by running ops on it.
  - Specific ops allow you to read and modify the values of this tensor.
  - Higher level libraries like tf.keras use tf.Variable to store model parameters. -- TensorFlow Docs

A lot could have changed since last update
Must Read: https://www.tensorflow.org/guide/variable

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