



# TENSOR... TENSORFLOW... AND... KERAS TOO...

Introduction to ML, DL, AI and OpenVino

Session 08

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## Agenda

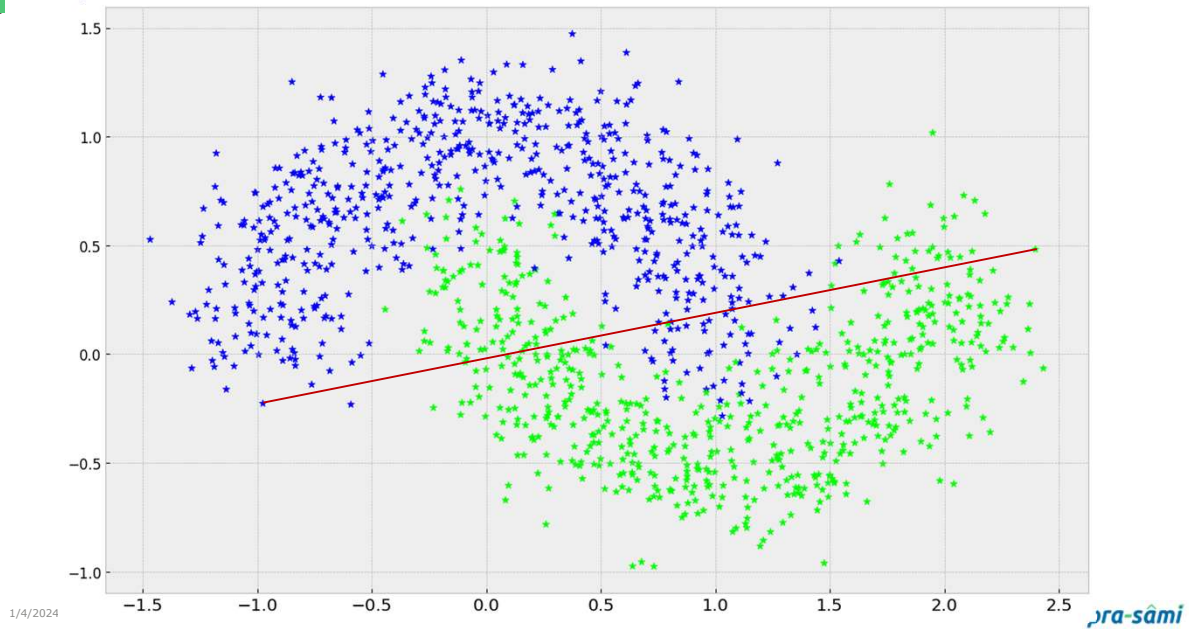


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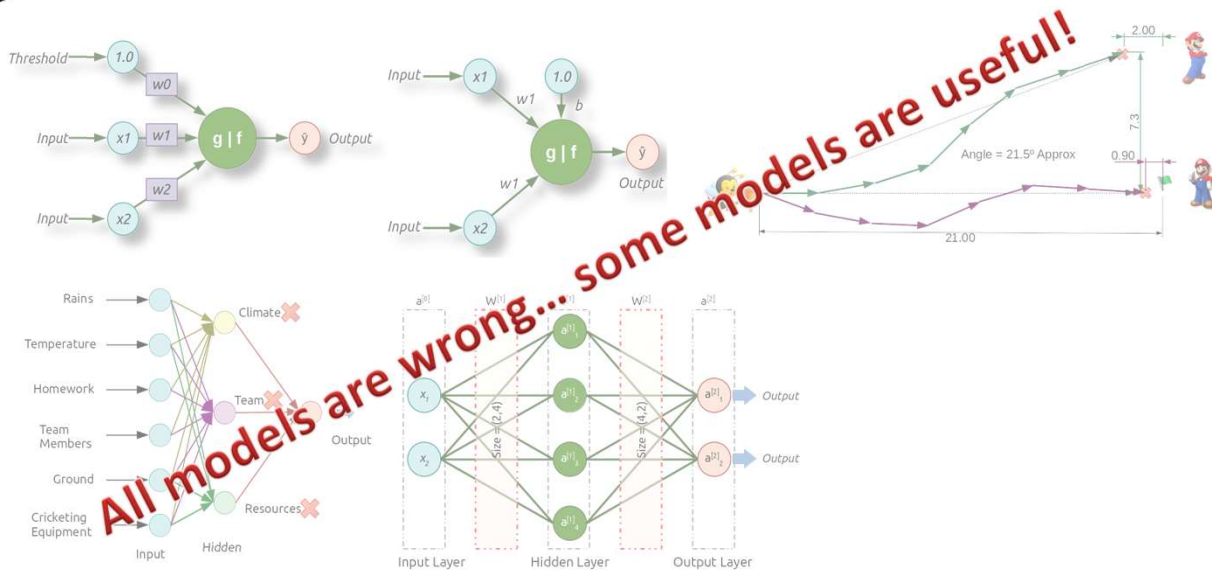
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## Story So far



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## Story So far...



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What is Tensor...

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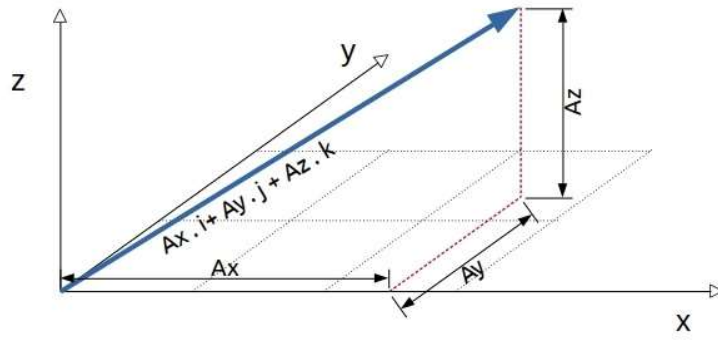
What is a vector???

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## Vector – Rank 1 Tensor



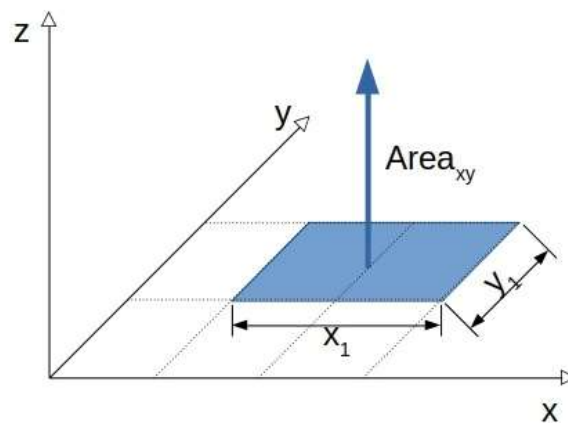
Tensor of Rank 1

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## Area too can be represented as vector....



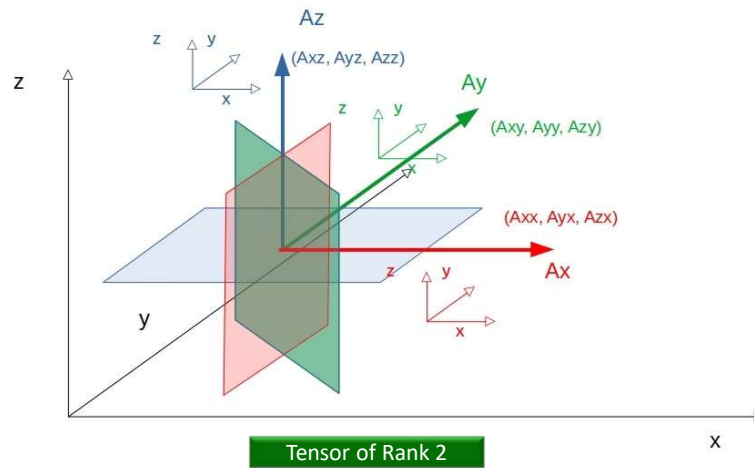
Area as a Vector

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Area can have three vectors attached to it...

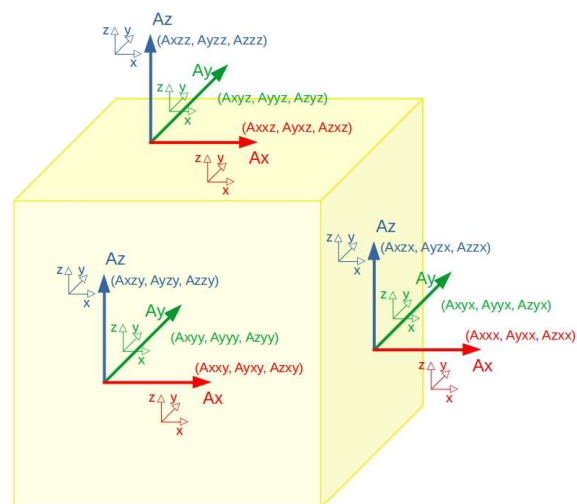


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So What is Rank 3 Tensor....



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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
$\geq 3$	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 of 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 its 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



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pandas



CuPy



matplotlib

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## Deep Learning Frameworks Landscape



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## Deep Learning Frameworks Landscape



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## Deep Learning Frameworks Landscape

  
 TensorFlow

  
 Sonnet

  
 DL4J


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 pandas

 CuPy



 GLUON

 Chainer



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## Deep Learning Frameworks Landscape

  
 TensorFlow

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 pandas

 CuPy



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## Deep Learning Frameworks Landscape



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## Deep Learning Frameworks Landscape



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## Deep Learning Frameworks Landscape

  
 TensorFlow

 PyTorch

 Keras

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 pandas

 CuPy

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## Deep Learning Frameworks Landscape

  
 TensorFlow

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 Keras

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## Deep Learning Frameworks Landscape

  
 TensorFlow

  
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 DL4J


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 PyTorch

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

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## 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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## Session Object

- ❑ 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 object represents the environment in which Tensor objects are evaluated" - TensorFlow
- ❑ `a = tf.constant(5.0)`  
`b = tf.constant(2.0)`
- ❑ `c = a * b`
- ❑ `with tf.Session() as sess:`  
`print(sess.run(c))`  
`print(sess.run(b))`



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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