Linear algebra

Scalars, vectors and 2nd-order tensors are the most essential mathematical objects in Anakin. The class `tensor` allows creating them.

Start by importing the Anakin framework into Matlab. Be sure to include Anakin's base directory before you run this line:

```
import anakin.*
```

Object creation

The default tensor is the null scalar:

```
v = tensor % default call
```

```
v =
Scalar with value:
     0
```

Scalars are created by passing the value to the constructor:

```
E = tensor(25) % example of scalar
```

```
E =
Scalar with value:
    25
```

Vectors can be created by passing their canonical components. Regardless of the shape of the input, the object stores the components in column form:

```
a = tensor([4;5;6]) % as a column vector
```

```
a =
Vector with canonical components:
     4
     5
     6
```

```
b = tensor([7,8,9]) % as a row vector
```

```
b =
Vector with canonical components:
     7
     8
```

```
     9
```

Similarly, one can create 2nd order tensors by giving their canonical component matrix:

```
T = tensor([1,2,3;4,5,6;,7,8,9])
```

```
T =
Second-order tensor with canonical components:
     1     2     3
     4     5     6
     7     8     9
```

Tensors and vectors can be given in another basis. Internally, the object stores only its components in the canonical basis:

```
B1 = basis([1;0;0],[0;cos(pi/6);sin(pi/6)],[0;-sin(pi/6);cos(pi/6)]);

a = tensor([0;1;0],B1)
```

```
a =
Vector with canonical components:
         0
    0.8660
    0.5000
```

```
T = tensor([1,2,3;4,5,6;,7,8,9],B1)
```

```
T =
Second-order tensor with canonical components:
    1.0000    0.2321    3.5981
   -0.0359   -0.0622    0.7679
    8.0622    2.7679   14.0622
```

For convenience, any object of tensor, point, frame class (or subclasses) can be passed as input to the tensor constructor. The result is converted to class tensor:

```
A = point; % a point object
a = tensor(A); % the position of the point, converted to vector
```

Basic functionality

To obtain the components of an existing object in a given basis, use the `components` method:

```
a.components % returns an array with the components of a in the canonical vector basis
```

```
ans = 3×1
     0
     0
     0
```

```
a.components(B1) % returns an array with the components of a in B1
```

```
ans = 3×1
     0
     0
     0
```

```
T.components(B1) % returns an array with the components of T in B1
```

```
ans = 3×3
    1.0000    6.9641    4.0622
    0.2321    2.3660    1.4378
    3.5981   12.5622    6.3660
```

Single components can be extracted direclty with method x. A basis can also be indicated as above:

```
a.x(1) % x component of a in the canonical vector basis
```

```
ans = 0
```

```
a.x(2,B1) % y component of a in B1
```

```
ans = 0
```

Vectors can be added, compared for equality, dotted, crossed, etc, and there are other useful methods that can be used:

```
a = tensor([1;2;0])
```

```
a =
Vector with canonical components:
     1
     2
     0
```

```
b = tensor([2;2;0])
```

```
b =
Vector with canonical components:
     2
     2
     0
```

```
c = a + b % sum vector
```

```
c =
Vector with canonical components:
     3
     4
     0
```

```
2*a % two times a
```

```
ans = 
Vector with canonical components:
     2
     4
     0
```

```
d = a - b % difference vector
```

```
d = 
Vector with canonical components:
    -1
     0
     0
```

```
dot(a,b) % dot product
```

```
ans = 
Scalar with value:
     6
```

```
e = cross(a,b) % cross product vector
```

```
e = 
Vector with canonical components:
     0
     0
    -2
```

```
T = product(a,b) % tensor product of two vectors
```

```
T = 
Second-order tensor with canonical components:
     2     2     0
     4     4     0
     0     0     0
```

```
a == b % compare two tensors
```

```
ans = logical
   0
```

```
a ~= b
```

```
ans = logical
   1
```

```
norm(a) % norm of a tensor (also accessible as magnitude(a))
```

```
ans = 
```

```
Scalar with value:
    2.2361
```

```
u = unit(a) % returns a unitary tensor in the same direaction as a
```

```
u = 
Vector with canonical components:
    0.4472
    0.8944
         0
```

```
isunitary(a) % returns true if the vector is unitary (this is false)
```

```
ans = logical
   0
```

```
isperpendicular(a,b) % returns true if the two vectors are perpendicular (this is false)
```

```
ans = logical
   0
```

```
isparallel(a,2*a) % returns true if the two vectors are parallel (this is true)
```

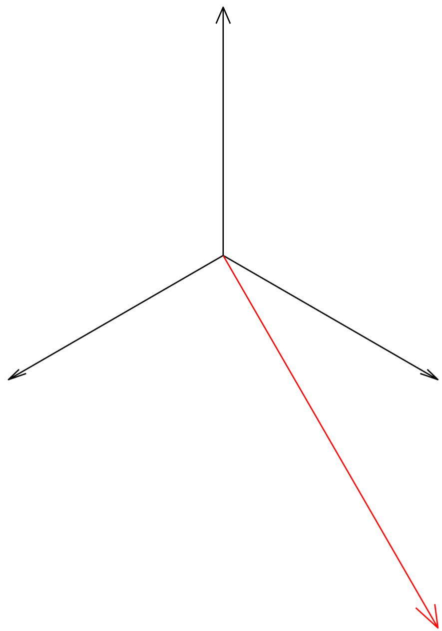
```
ans = logical
   1
```

Finally, a numeric vector can be plotted using `plot`:

```
ax = axes('DataAspectRatio',[1,1,1]);
ax.XAxis.Visible = 'off';
ax.YAxis.Visible = 'off';
ax.ZAxis.Visible = 'off';
view([1,1,1]);

basis().plot; % plot the basis for reference

a = tensor([1;2;0]);
a.plot('color','r'); % pass quiver3 plotting arguments to change color, style, etc.
```



Symbolic objects

Objects with symbolic components have additional functionality (running this requires the Symbolic Math Toolbox installed):

```
syms t theta(t) phi(t); % declare symbolic variables
assume([in(t, 'real'), in(theta(t), 'real'), in(phi(t), 'real')]);

a = tensor([cos(theta),sin(theta),0]) % a rotating vector
```

```
a =
Vector with canonical components:
 cos(theta(t))
 sin(theta(t))
             0
```

One may compute the time derivative of a symbolic object with respect to a chosen basis or reference frame with method `dt`. The result is an object of the same type. If no basis/reference frame is provided, the canonical one is assumed:

```
a.dt % time derivative of a in the canonical reference frame
```

```
ans =
Vector with canonical components:
```

```
 -sin(theta(t))*diff(theta(t), t)
  cos(theta(t))*diff(theta(t), t)
                                0
```

```
O = point([0,0,0]);
B1 = basis([1;0;0],[0;cos(phi);sin(phi)],[0;-sin(phi);cos(phi)]);
S1 = frame(O,B1);

a.dt(S1) % time derivative of a in S1
```

```
ans =
Vector with canonical components:
 -sin(theta(t))*diff(theta(t), t)
  cos(theta(t))*diff(theta(t), t)
   -sin(theta(t))*diff(phi(t), t)
```

To particularize a symbolic object at particular values of its parameters, one may use `subs`, by specifying them in a list:

```
a.subs({theta,t},{pi/6,0}) % replace theta with pi/6, and t with 0
```

```
ans =
Vector with canonical components:
    0.8660
    0.5000
         0
```